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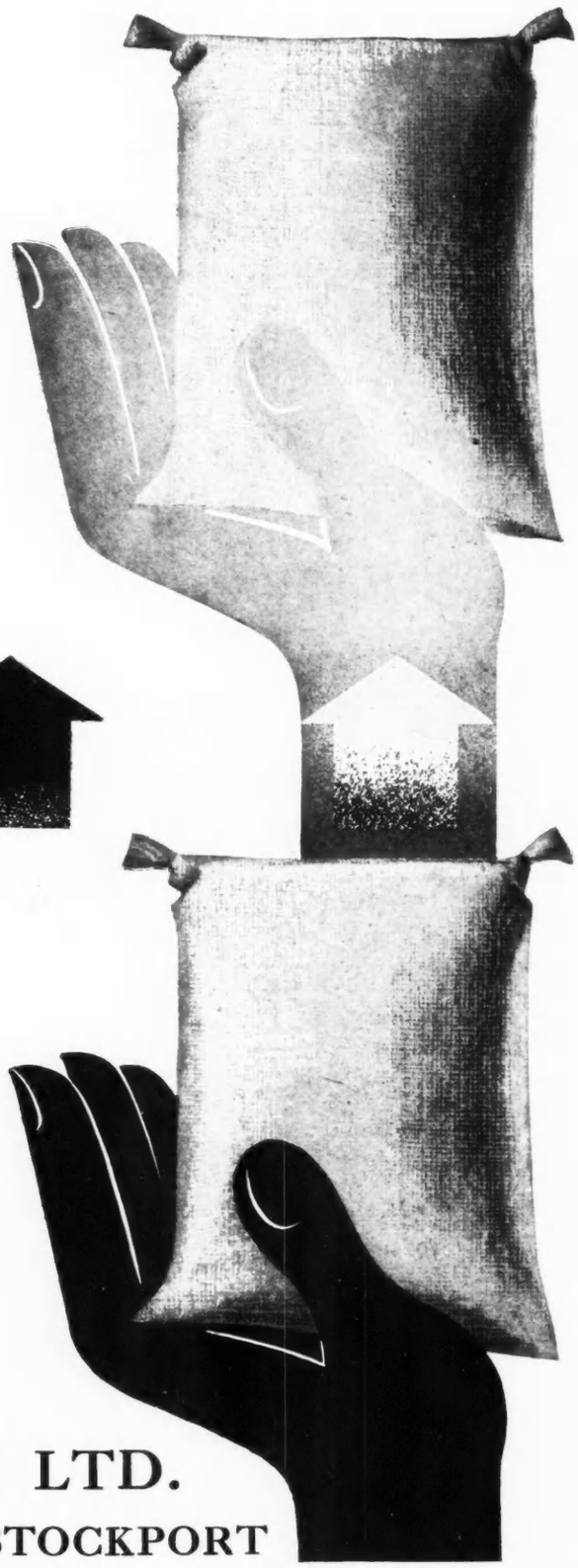

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ATTENUATION OF SOUND IN LINED AIR DUCTS.

By C. P. BRITTAIN, Grad.I.E.E., C. R. MAGUIRE, B.Sc., A.M.I.E.E., R. A. SCOTT, Ph.D., F.Inst.P., and A. J. KING, D.Sc., M.I.E.E., F.Inst.P.

THE need for comprehensive data on the attenuation of sound in lined air ducts has already been pointed out* and a description given† of part of an investigation of the problem carried out in the Research Department Acoustics Laboratory of the Metropolitan-Vickers Electrical Company, Limited. Some preliminary results of tests on ducts of practical dimensions and with various linings were also given and these confirmed, by the large variation in attenuation with frequency, width of air space and character of lining which they showed, the importance of being able to determine with certainty the attenuation of sound at any frequency in a given duct. To this end, the investigation in the above laboratory proceeded simultaneously along two channels: a theoretical investigation and an experimental investigation. The former has been described recently for straight ducts in three papers‡ to the Physical Society, and it is the purpose of the present article to record the latter. The theoretical inquiry gave an expression for the sound attenuation in a straight duct in terms of its dimensions and the acoustical impedance of the lining material similar in certain cases to that given by Morse.* The difference is that Morse does not take into account transmission of sound along the duct in the lining material, with the result that his expression gives attenuation figures which are too high for a narrow duct, where attenuation in the air passage is high and leakage along the lining becomes important. However, in most practical cases, the expression for attenuation given by Morse provides results which are sufficiently accurate for design purposes and it is much easier to use than that given by the more complete theory.

It was apparent from the early work above referred to that the curves of attenuation against frequency for ducts with linings of porous material have a characteristic shape, indicating low attenuation at low and high frequencies with a more or less pronounced peak in between. This general trend is to be expected in ducts of practical dimensions for the reasons outlined below. At low frequencies the attenuation that can be produced in a duct lined with porous material is low, mainly owing to the comparatively high acoustic impedance of porous linings of practicable thickness. Reduction of this impedance increases the motion of air in the porous material, thereby increasing the viscous dissipation of energy in the sound wave and hence also the attenuation. The impedance is determined largely at low frequencies by the reactance of the air in the porous material. This reactance, which is negative in sign, can be reduced by combining with it the positive reactance of a cover sheet of appreciable mass and negligible stiffness. By a suitable choice of mass, the net reactance at a particular frequency can be made zero, making the impedance at the surface at that frequency resistive and low. Useful attenuation might be expected, therefore, at selected frequencies in a duct lined with a succession of diaphragms, each made resonant at a desired frequency by an enclosed volume of air behind it.

At high frequencies, where the wavelength is less than the width of the air space, transverse waves are rapidly absorbed at the beginning of the duct and the sound propagated along the duct consists mainly of a beam of axial waves. This beam tends to keep to the middle of the duct and is affected little by the absorbent walls. Since a bend in a duct creates a disturbance involving transverse waves it was expected that the incorporation of bends in ducts would increase the sound attenuation materially in cases where, for structural or other reasons, wide air passages are essential. Unlike straight ducts, no satisfactory quantitative analysis of the sound attenuation produced at a bend has been made, and therefore no quantitative theoretical predictions can be made.

It was clear then that, for a complete survey of the problem, an experimental investigation would have to cover the attenuation of sounds in straight and bent ducts lined with porous material and in straight ducts lined with low-frequency resonators. The experimental technique which has been described was followed in the main, but as the investigation proceeded several improvements were suggested by experience. It was found unnecessary to retain the rotating sound source, since the preliminary duct absorbs transverse waves rapidly. Without

Fig. 1.

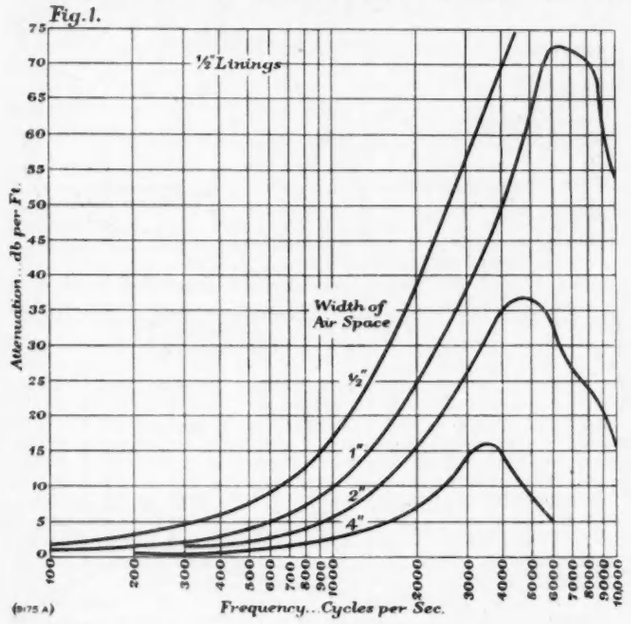


Fig. 2.

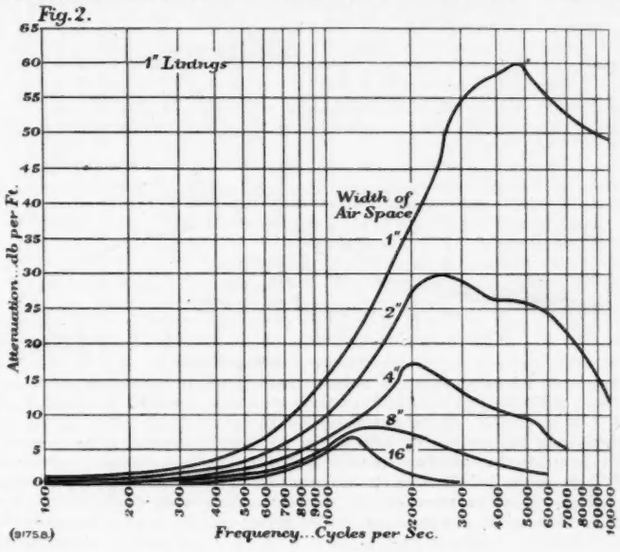


Fig. 3.

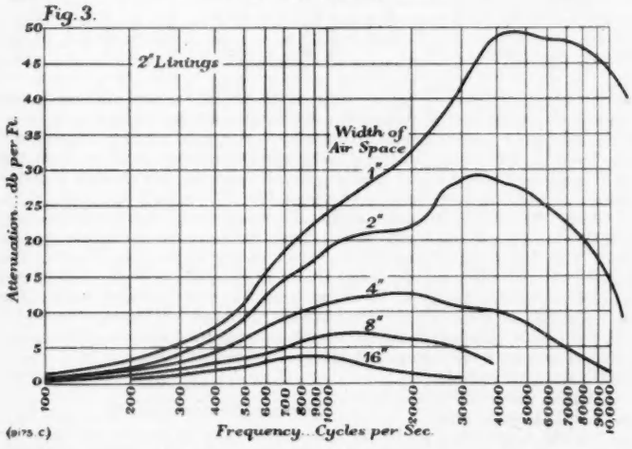
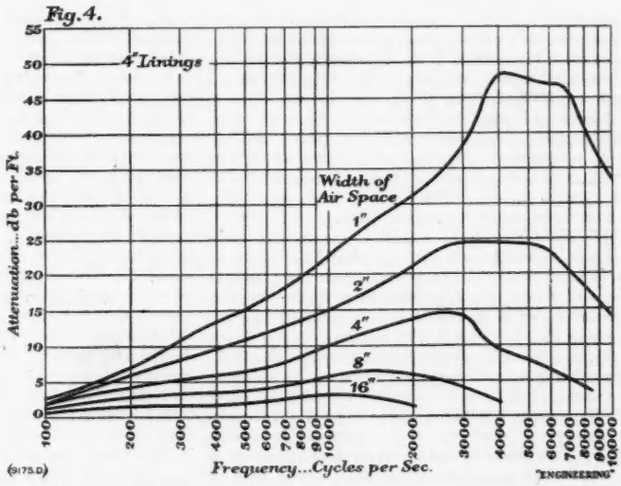


Fig. 4.



* ENGINEERING, vol. 157, page 501 (1944).

† *Ibid.*, vol. 156, page 221 (1943).

‡ *Proc. Phys. Soc.*, vol. 58, pages 165, 253 and 358 (1946).

* *Jl. of Acoustical Soc. Am.*, October, 1939, page 205.

SOUND ATTENUATION IN AIR DUCTS.

Fig. 5.

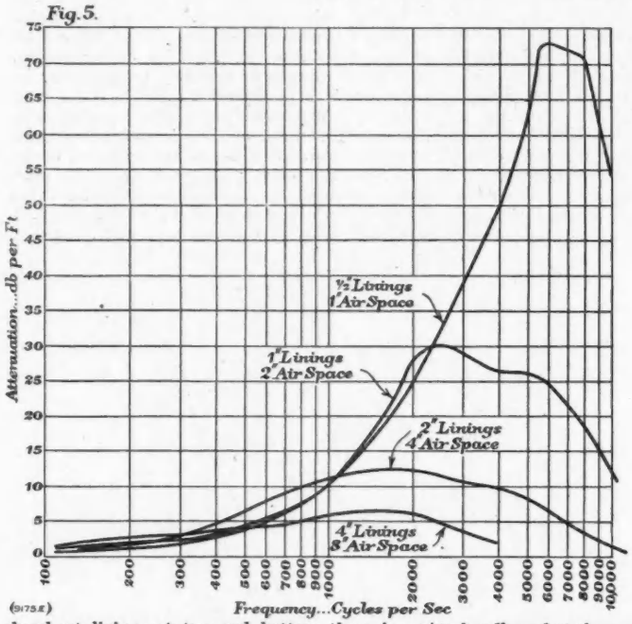


Fig. 6.

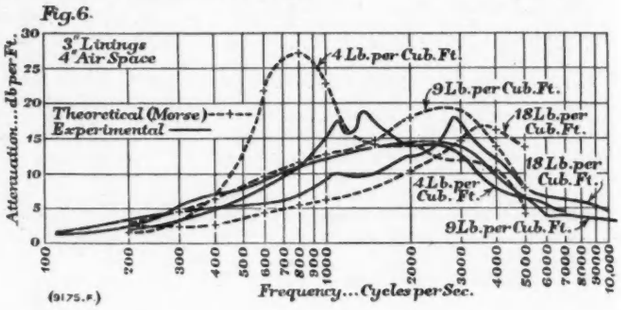
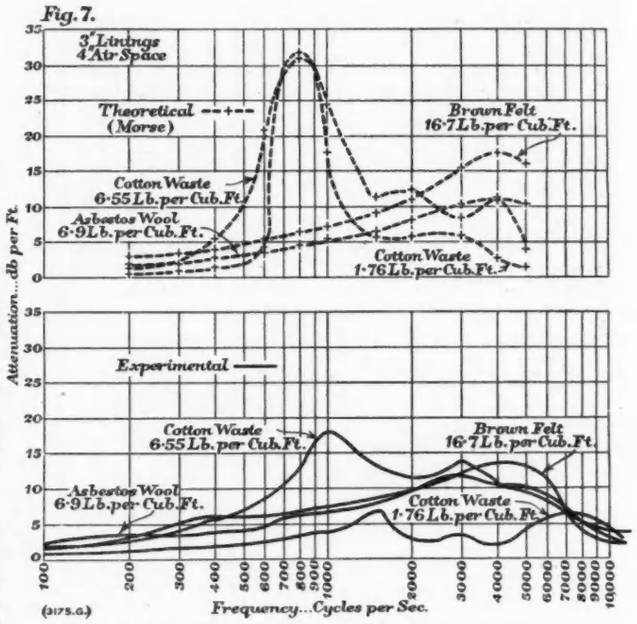


Fig. 7.


3" Linings 4" Air Space
Theoretical (Morse)
Brown Felt 16·7 Lb. per Cub. Ft.
Cotton Waste 6·55 Lb. per Cub. Ft.
Asbestos Wool 6·9 Lb. per Cub. Ft.
Cotton Waste 1·76 Lb. per Cub. Ft.
Attenuation...db per Ft.
Experimental
Cotton Waste 6·55 Lb. per Cub. Ft.
Brown Felt 16·7 Lb. per Cub. Ft.
Asbestos Wool 6·9 Lb. per Cub. Ft.
Cotton Waste 1·76 Lb. per Cub. Ft.
(9175.G)
Frequency...Cycles per Sec.

absorbent linings at top and bottom there is no correspondingly large attenuation of waves inclined to the horizontal; hence the necessity at some frequencies for vertical exploration of the sound field to obtain the average pressure at each distance. Such averaging is best done on an energy basis, so readings of sound pressure were taken on an instrument with a square-law scale, giving an approximation to the energy basis.

Numerous data relating to the attenuation of sound in straight ducts lined with porous material have been obtained and condensed into curves to show the effect of frequency, duct width and thickness of lining. Figs. 1 to 4, page 97, give the experimental results obtained with varying frequency and width of air space for geometric increments in thickness of lining from ½ in. to 4 in. The large range in attenuation, from over 70 to less than 1 db. per foot, is apparent. The absorbent material used in these tests is a proprietary form of rock wool with an average density of 13·7 lb. per cubic foot. The effect of density is referred to later.

If considerations of available space, net cross section required and cost of absorbent combine to confine attention in a given case to a certain ratio of width of air passage to total duct width, the curves of Figs. 1 to 4 can be reduced to a set such as Fig. 5. This family of curves is for 50 per cent. net air cross section and illustrates the wide variation in relative emphasis which can be obtained on sound of different frequencies by suitable choice of dimensions but maintaining the effective cross-section ratio constant. For a given cross section of air path, the choice of a narrow duct may require a number of passages in parallel. If the case of two similar lined ducts operating side by side in parallel is considered, symmetry would suggest that the two adjacent walls can be removed, leaving the two intervening linings back to back, without substantially altering the sound attenuation. It has been demonstrated in the present investigation that this is, in fact, the case, a rectangular duct with a certain width of air space and 1 in. linings, for example, giving the same attenuation-frequency curve as a larger duct subdivided by 2-in. splitters to give air passages of the same width. This result is important as the one set of curves applies to both linings and splitters, remembering that the latter are twice as thick as the former.

The effect of the tightness of packing of the absorbent linings or splitters on the attenuation of sound in a duct is illustrated in Fig. 6, which covers the range 4 lb. to 18 lb. per cubic foot in rock wool. This range is greater than is likely to be met in practice as the material at the lower limit is difficult to handle and at the upper limit is compressed very tightly. The relative effectiveness of the three densities tested varies with frequency, but the intermediate density of 9 lb. per cubic foot is rather more consistent in attenuation with frequency than the others.

Fig. 6 also provides a comparison between the experimental results and the values of attenuation calculated from Morse's theory. The manner in which the theoretical values are obtained from a knowledge of the acoustic impedance of the lining material has been described in the paper referred to. It is seen that for the medium and dense linings there is a fair measure of agreement between theory and experiment, but that the large attenuations indicated by Morse's theory for the light material in the region 500 to 1,000 cycles per second are not attained in practice. This tendency of Morse's theory to indicate higher values of attenuation than are realised in practice for light absorbent linings and splitters is to be expected, as already mentioned. It means that, in the case considered, for sound of 500 to 1,000 cycles per second, more is transmitted in the 4 lb. per cubic foot lining material than along the air passage, and it is transmission in the lining, and not along the air passage, that determines the performance in this and similar cases. It was realised, therefore, that for this and certain other noise-suppression problems, data concerning the attenuation of sound in bulk porous materials are important and experimental determinations were carried out as described elsewhere.* Table I

TABLE I.—*Attenuation in Bulk Rock Wool at Different Frequencies.*

Frequency, Cycles per Sec.	Attenuation, in Db. per Ft.
100	24
200	31
400	40
800	53
1,600	71
3,200	92
6,400	116

gives values obtained with a rock wool sample of density 10 lb. per cubic foot. An examination of the experimental results showed that within the density range 5 lb. to 25 lb. per cubic foot, the attenuation of sound in db. per foot in bulk specimens of rock wool is approximately proportional to the density of the rock wool and so, from the information given in the table, it is possible to derive values of attenuation in the bulk material over a wide range of frequencies and densities. An indication of the performance of other porous materials as duct linings is given in Fig. 7. The upper curves are calculated from Morse's theory and the lower curves are the result of experiment. The high attenuations predicted by Morse's theory for light porous linings in narrow ducts are again illusory and not attained experimentally.

(To be continued.)

* *loc. cit.*

EXPORT CREDITS GUARANTEE DEPARTMENT.—During the quarter ended December 31, 1947, the Export Credits Guarantee Department assumed liability, under Section 1 of the Export Guarantees Act, 1939, and under Section 2 of the Export Guarantees Act, 1945, up to a maximum of 22,572,682*l.*, in respect of contracts, policies and guarantees amounting to 43,731,599*l.*

IRON AND STEEL DISTRIBUTION SCHEME.—The revised arrangements for authorising iron and steel supplies, which will come into force on Thursday, April 1, are described in a circular which is being issued to consumers by the Government departments concerned. This circular, which also gives consumers instructions as to procedure, is being distributed not only to firms who receive an authorisation directly from a department, but to those in the metal-using industries whose addresses have been obtained in connection with the Census of Production. It is hoped in this way to reach the majority of firms who derive their authority for iron and steel supplies by sub-authorisation. Any user of iron and steel who has not received a copy of this circular should apply to the Iron and Steel Board (S.B.1), Bush House, Strand, London, W.C.2.

LITERATURE.

Electronics and Their Application in Industry and Research. Edited by DR. BERNARD LOVELL, O.B.E., B.Sc., F.Inst.P. The Pilot Press, Limited, 45, Great Russell-street, London, W.C.1. [Price 42*s.* net.]

FOR a number of years prior to 1939, as well as throughout the whole of the war, an important proportion of the world's scientific talent was engaged in advancing the theory and practical applications of electronic physics; so busily and secretly engaged that relatively little of what was discovered has had time hitherto to become known to more than specialists in the subject. Nevertheless, from the few items of information now in general circulation, industrial research workers are gradually becoming aware of isolated developments from which it is possible to infer something, and to imagine a great deal more, of what modern electronics has to offer in the way of increased scope and improved techniques for examining, testing, measuring and controlling the materials and operations with which they are immediately concerned. Such workers are already well-grounded in the fundamentals of electronics and competent to tackle extensions of theory as well as of practice. What they want, therefore, is an adult presentation of the new work in such a form that each subdivision of the subject is compactly and critically surveyed, the points of major importance emphasised, and the whole well documented.

This is the worthy objective aimed at and notably well achieved by the work under review. Its attainment demanded the united effort of a team of specialists, and, under the general editorship of Dr. Lovell, of the physical laboratories at Manchester University, each of its 14 chapters is the work of an authority thoroughly steeped in his subject and conversant with all relevant literature. The editor's task has been to standardise the nomenclature and symbols, to append some tables of physical constants common to the whole book, and to contribute an attractive introduction in which the growth of electronics is traced from the discovery of the electron to the thermionic valve, through the revolutionary changes of the past 25 years, and especially during the war, and so to the speculative future. Dr. F. A. Vick presents a compact general picture of electron physics, ranging from accepted fundamental theory to modern ideas of electron emission and photo-conductivity. Dr. H. G. Lubszynski and Dr. A. Elliott deal, respectively, with photo-cells for the visible and ultra-violet, and for the infra-red ranges of radiation. Instructive discussions of photo-voltaic apparatus for picture transmission, and the applications of lead-sulphide cells, serve to introduce an excellent account of the electronic generation of television signals, in which Dr. J. D. McGee describes some of the most modern equipment. Dr. F. C. Thompson's account of thermionic valves for very high frequencies includes good descriptions of the klystron and the magnetron. A remarkably fine chapter by Dr. R. A. Smith covers the theory and practice of "radar," and includes some inspiring ideas regarding the future applications of pulse repeaters and navigational systems, and the impact of radar generally on the advance of science.

What may be regarded, perhaps, as the more tangible engineering uses of electronics are dealt with in the remainder of the book. Mr. L. Atkinson illustrates his account of the control applications of cold-cathode valves, for instance, by references to counting equipment, stroboscopes, and apparatus for depth-sounding and high-speed flash photography. High-frequency dielectric heating, and electronic moisture-control equipment, described by Mr. H. Wood, are already used, and have a rapidly extending field of utility, in numerous industries. Engineers are also intimately concerned with electronic servo-control mechanisms, which Mr. F. H. Belsey discusses comprehensively; and if they are not directly concerned with electronics applied to medicine and physiology, they will find much to interest them in the accounts of such developments by Dr. L. G. Grimmett and Dr. R. J. Pumphrey. The betatron, described by Dr. J. O. Craggs, is something for an engineer to make rather than to use, but he can appreciate its potential services to atomic science; and if he follows all that Dr. V. E. Cosslett has to say about electron diffraction and microscopy, in a final chapter that is a veritable text-book in itself, he will be convinced of the important part that these techniques are shortly going to play in industrial research.

It is hardly necessary to add that the style and quality, both of the text and illustrations, are commensurate with the talents of the contributors to this fine compilation, all of whom combine profound scientific knowledge with an enviable gift for clear and concise exposition. The outcome is an outstanding work which cannot fail to have a considerable influence on the expansion of electronic methods in engineering and industrial practice, as well as over the whole range of physical research.

Practical Yacht Construction. By C. J. WATTS. The Rolls House Publishing Company, Limited (distributors for Robert Ross and Company, Limited), 2, Breams-buildings, London, E.C.4. [Price 21*s.* net.]

STEEL, as a shipbuilding material, has a history of not much more than three-quarters of a century, and iron, for vessels other than barges, goes back about another 50 years, but the antiquity of wood shipbuilding has not been determined yet with even approximate accuracy, nor is it likely to be. The practice of building in wood, however, has been the subject of comparatively few text-books at any time and it is probably not far wrong to state that no standard work on the subject has been written or even reprinted within living memory; certainly none that can be compared in detailed thoroughness with this book by Mr. Watts, who brought to his task all the varied experience of 28 years as chief draughtsman to Messrs. Camper and Nicholsons, Limited, of Southampton.

The book comprises six chapters, with the addition of three tables giving, respectively, proportions of spars, standard sizes of standing rigging, and a list of the blocks required for a 13-ton Bermuda-rigged cutter. The first four chapters are concerned almost entirely with the details of wooden construction and of rigging, the fifth covering internal equipment, classification, auxiliary propulsion, etc., and the last dealing with such miscellaneous matters as tonnage measurement, internal ballast, the composite and double-skin methods of construction, and the use of resin-bonded plywood for boat hulls—"glued shavings," to use the author's term. Line diagrams and sketches are employed freely and effectively, and are liberally sprinkled with explanatory notes which repay a careful study; many of them embody little practical hints for which some quite well-known works may be searched in vain. The insertion of folding plates is ingeniously avoided by using the end-papers to display, at the front of the book, construction plans for a 20-ton cutter and, at the back, the plumbing system for an 80-ton auxiliary yacht. The only criticism we would make is that Table I, which is entitled "Dimensions and Proportions of Spars (Actual Cases)," would be better for an overhaul, a less comprehensive title (the table contains no relative lengths of spars), some explanatory notes and, perhaps, references to an accompanying key diagram. At present, many readers are likely to find it difficult to follow, and it contains a number of errors in type-setting; particularly in the "Item" column which has "*Spinnaker*" on the top line, but the "*Boom*" belonging to it, two lines farther down. "*Square Sail Yard*," "*Pole Mast*" aud "*Topsail Yard*" are similarly maltreated. There will be opportunity to amend this table, however, in the future editions which we are reasonably confident will be required.

L.M.S. ASSETS IN NORTHERN IRELAND.—The former assets of the London Midland and Scottish Railway Company in the Northern Counties Committee became the property of the British Transport Commission on January 1, 1948. The first step towards the acquisition of these assets from the Commission was taken on January 16, 1948, when Sir Roland Nugent, Northern Ireland Minister of Commerce, and Mr. G. H. E. Parr, Permanent Secretary to the Ministry, had a preliminary discussion with Sir Cyril Hurcomb, chairman of the Commission. If the negotiations are successful, the assets will vest in the Northern Ireland Transport Authority, which it is proposed to set up.

THE ENGINEERING OUTLOOK.

V.—AGRICULTURAL MACHINERY.

THE agricultural machinery industry is in the throes of a revolution. The impact of an invention has shattered the traditional placid conservatism of the industry and brought to the fore a small number of dynamic groups which promise to dominate future developments and are rapidly increasing the importance of agricultural machinery in the national economy.

The invention is the automatic implement lift, now attached to the products of all leading tractor manufacturers, by means of which specially designed implements are mounted so that tractor and implement become, for operational purposes, a single unit. Invented by Mr. Harry Ferguson, the principle was first developed by him before the war in conjunction with David Brown (Huddersfield), Limited. Although the partnership proved shortlived, the Huddersfield firm continued work on the project and David Brown Tractors, Limited, was formed for the purpose. Mr. Ferguson meanwhile interested Henry Ford, sen., in the idea, and the River Rouge plant in the United States began in 1940 the manufacture of tractors to Ferguson designs. The seven-year alliance which followed lifted the American Ferguson company, Harry Ferguson, Incorporated, to a prominent position in the United States industry, and, before the Ford Ferguson agreement came to an end last June, the Ford Motor Company in the United States built 250,000 Ferguson tractors. At the same time, Ferguson had implements built under contract on a scale which made his total turnover in tractors and implements around 10,000,000 dols. a month, or rather more than the entire output of the British agricultural machinery industry at the time.

In this country, the Ford Motor Company quickly realised the importance of attaching a hydraulic lift to their tractors, but chose not to use the Ferguson design. Harry Ferguson, Limited, however, was formed to apply the methods which had been successful in the United States to the British industry, and in the summer of 1946 the first British-built tractors to the Ferguson design were completed by the Standard Motor Company at Coventry. Since then, the output of the Standard-Ferguson tractor has risen steadily to about 250 a day. Meanwhile, the Ford Motor Company, who had a near-monopoly of tractor production during the war, have raised their output from 120 a day a year ago to over 200 a day. Ford production plans promise still further increases in output and a new factory for the purpose is being built at Dagenham.

At the beginning of 1948, therefore, these two leading tractor manufacturers were producing at the rate of about 110,000 machines a year. To this must be added the David Brown (Tractor) output, currently around 3,500 a year; that of Marshall Sons and Company, at Gainsborough, believed to be of the same order; and a smaller output from Minneapolis Moline England, Limited, making a total rate of output of about 120,000 tractors a year.

Table I, on page 100, compiled from figures issued by the Ministry of Agriculture and Fisheries and the Ministry of Supply, shows the output for certain types of agricultural machinery in recent years, and will serve to show the magnitude of the expansion still taking place. The total tractor output in 1946 was less than a quarter of the present rate, and, even since the third quarter of 1947, the rate of production has been doubled. The table also makes it clear that the rate of expansion of tractor output has far exceeded that achieved in the implement sections of the industry, and this fact alone indicates the growing importance of tractor makers, who, little more than ten years ago, were scarcely considered to be agricultural machinery makers.

The influence of the tractor makers, in fact, extends much farther than the figures reveal. The development of unit-mounted implements requires that they should be manufactured to the tractor makers' design and this, for the most part, has been achieved by contracting out. Harry Ferguson,

Limited, for example, have six firms making equipment to work with the Standard-built tractor. The Ford Motor Company, who made no implements before the war, purchased a foundry at Leamington during 1945 to produce implement castings. At the same time, the Ford Company came to an arrangement for the joint design of implements, and joint field tests, with a number of implement-making firms. The list has been greatly expanded during 1947 and at present includes 17 implement-making concerns, headed by Ransome, Simms and Jefferies, Ipswich. On a smaller scale, David Brown Tractors, Limited, now have implement-making arrangements with four outside firms, while they themselves acquired a new works at Farley, near Leeds, during 1947, solely for implement manufacture, and the output there is already of the order of 15,000 units a year.

Despite these developments, the output of tractors is at present far outstripping supplies of implements, both of the unit-mounted type and of other descriptions. Tractor makers, therefore, intend to increase the output of implements which are supplementary to their own products, and, in 1948, it is likely that there will be new sub-contracting arrangements between tractor and implement makers, as well as extensions of existing agreements. In other words, the process of horizontal integration in the industry is likely to continue and the satellite firms will become more and more dependent upon the success of the tractor makers for the sale of their products. For the present, so long as the sellers' market continues, these arrangements are likely to remain in their existing form, but, should marketing conditions become difficult, it seems probable that there would be amalgamations between the members of the satellite groups and partial or complete financial absorption by the parent tractor firms. It appears likely, therefore, that the changes which are taking place in the industry are still in their early stages, and that the coming years may well see the development of a process of rationalisation brought about by the development of the unit principle.

In the immediate future, however, there is little prospect of a market recession. The Marshall economic policy demands tractor and implement supplies for Europe far beyond the United States' exportable surplus, and it will naturally fall to this country to fill a large part of the gap. Even more encouraging from the export point of view was the recent announcement of an order for 20,000,000 dollars' worth of Ferguson tractors, received from the United States. There is, perhaps, a little more behind this than is immediately apparent. The arrangement to which reference was made above, between Harry Ferguson, Incorporated, and the Ford Motor Company in the United States, came to an end last June. The American Ferguson concern, however, with over 100 sub-contracting arrangements for implements and other tractor equipment, scattered throughout the United States, was in no mood to abandon the tractor market permanently. Accordingly, a search was begun for a new partner to build a tractor to Ferguson design, and, despite hopeful news items in the American Press from time to time, it appears that a satisfactory arrangement has not yet been concluded. The tractors ordered for the United States this January, therefore, appear to be in the nature of a stop-gap consignment for the transatlantic Ferguson concern, which will enable tractor sales to be maintained pending the resumption of manufacture in the United States.

It is a matter of national importance to this country to know whether or not there is a hope of the Ferguson-Standard combine over here retaining a permanent share of the American market. The two controlling factors are evidently cost of production and the supply of raw materials and sub-assemblies. On the cost issue, it is noteworthy that no public statement has been made from Coventry; indeed, the most enthusiastic supporters of this new development in British export trade claim no more than that costs over here "compare favourably" with the costs of building a similar tractor in the United States. Even so, the rapid expansion of the Ferguson-Standard output must bring sharp reductions in costs, and the extent to which this development can be carried will depend on supplies of raw materials. The Coventry expansions to date could not have been achieved without the Government's blessing, made manifest through liberal steel allocations; and the announcement of the American order coincided with a statement by Sir Stafford Cripps that agricultural machinery would receive "a very substantial increase" in steel supplies in the near future. The publicity associated with the dollar order seems likely to ensure that Ferguson's claim to a large share of the increased supplies will be pressed to the utmost, and, to the impartial observer, dollar successes on this scale make the claim appear a good one.

Meanwhile, 20,000,000 dollars' worth of British tractors are to be delivered in the next five months, a total of perhaps 7,000 to 8,000 machines. Apart from steel supplies, Ferguson development has been limited by the supply of engines. Tooling up of the Standard factory to make the tractor engine has been a slow process, and the current rate of engine output at Coventry is about 140 a day. The remaining requirements, currently about 110 engines a day, are made up by imports from the Continental Motor Corporation in the United States. British-made engines are sufficient to supply the home market and the eastern hemisphere, and tractors exported to the United States, therefore, will be carrying American-built engines across the Atlantic for the second time. This anomaly could obviously be righted by exporting engineless tractors in which the power units would be installed in the United States, and this, in fact, is likely to happen, failing a substantial increase in engine output at Coventry.

Ferguson tractor production by the Ford Motor Company in the United States averaged about 35,000 per annum during the seven years of the agreement, and presumably supplies on this scale would be necessary to secure the market permanently for the British firm. The present contract entails deliveries to the United States at the rate of 400 a week, and to supply the full requirements of Harry Ferguson, Incorporated, would require delivery at nearly twice that rate. The production capacity is sufficient to make this possible, and it seems likely that the material will be forthcoming. There remains the question of costs, and the likely increases in scale of production offer a real prospect of costs being reduced to a level at which permanent competition in the United States market will be possible. In this connection it is noteworthy that the announcement of the American order was closely followed by a substantial cut in the retail price of the Ferguson tractor.

TABLE I.—PRODUCTION OF AGRICULTURAL TRACTORS, MACHINES AND IMPLEMENTS.

	Tractors.		Mouldboard Ploughs.		Disc Harrows.†	Corn Drills.	Mowers.	Potato Spinners.†	Threshing Machines.	Combine Harvesters.	Milking Machines.	Total.‡	For Export.
	Agricultural Types.	Market-garden Types.*	Tractor-drawn.	Horse-drawn.									
	Number.											Value, 1,000*l.*	
1937	17,949	461	6,054	14,695	1,323	394	4,436	1,767	518	—	—	—	—
1938	10,029	650	5,156	7,424	1,260	342	4,641	1,496	486	—	—	—	—
1939	14,662	1,071	7,124	9,541	2,108	664	5,587	1,253	489	—	—	—	—
1940	17,925	1,391	8,680	14,492	3,905	1,567	7,087	2,108	842	—	—	—	—
1941	22,168	2,233	10,495	14,162	5,696	1,452	5,896	5,226	998	—	—	—	—
1942	24,147	2,909	8,929	12,485	8,343	1,262	5,910	7,534	1,149	—	4,582	—	—
1943	21,682	3,377	8,307	10,939	9,791	1,176	5,611	9,831	1,149	4	5,623	—	—
1944	18,849	4,173	9,738	13,963	10,521	1,353	5,802	5,586	1,160	1	4,888	—	—
1945	17,500	5,796	12,882	17,345	12,940	1,743	6,297	6,021	1,083	107	4,807	—	—
1946	28,796	18,250	18,305	81,642	11,966	3,254	9,338	5,757	1,197	125	6,014	26,281	6,137
1945, 1st Qr. ..	4,596	1,171	2,889	5,605	4,767	640	1,605	284	227	—	966	—	—
2nd ,, ..	3,415	1,287	2,499	4,526	3,244	202	1,730	724	280	5	1,361	—	—
3rd ,, ..	3,668	1,567	2,716	2,244	1,930	357	1,314	2,416	258	59	1,104	—	—
4th ,, ..	5,821	1,771	4,778	4,970	2,999	544	1,648	2,597	318	43	1,376	4,748	847
1946, 1st ,, ..	6,000	2,872	4,598	26,838	2,354	807	1,971	93	247	13	1,100	5,560	1,226
2nd ,, ..	7,298	3,944	4,328	19,688	2,837	688	2,790	1,103	296	46	1,640	6,700	1,793
3rd ,, ..	6,597	5,002	4,196	22,085	2,594	1,134	2,012	3,045	279	32	1,588	6,435	1,639
4th ,, ..	8,901	6,432	5,183	13,031	4,181	625	2,565	1,516	375	34	1,686	7,586	1,479
1947, 1st ,, ..	8,308	4,974	5,151	6,625	2,580	740	1,998	452	304	73	1,462	6,827	1,350
2nd ,, ..	13,170	6,683	8,115	10,369	2,203	408	3,376	468	321	133	1,862	10,274	1,538
3rd ,, ..	14,335	7,084	10,774	8,568	2,671	616	3,067	1,950	358	80	2,105	10,834	2,385

* Includes small tracklayers. † The figures for 1945 have been revised. ‡ Including value of items not shown separately in preceding columns.

Sir Stafford Cripps gave no quantitative indication of the increased allocation of steel to be expected. Some idea of the present scale of consumption may be derived from a statement, made by the Ministry of Supply in the summer of 1947, that, thenceforward, approximately 2 per cent. of the country's steel would be used for the manufacture and repair of agricultural machinery. Figures for previous years were at the same time quoted at 1·3 per cent. in 1945 and 0·8 per cent. in 1941. In his recent analysis of the steel position, Sir Stafford Cripps put the likely level of demand for finished steel in 1948 at about 11,500,000 tons, of which he said the effective home demand, after allowance for net exports, might be put at 10,500,000 tons. Two per cent. of this would give this industry 210,000 tons of steel in 1948, but, making allowances for the "very substantial increase" promised by Sir Stafford, the industry can probably look for deliveries totalling some 300,000 tons.

Sir Stafford, however, said nothing about supplies of iron castings, though many manufacturers found them more stringent than steel supplies during 1947. Typical delivery dates for manufactured supplies during the latter half of 1947 were, for iron castings, four to 11 months; for steel strip, six to 16 months; for steel tube, six to 10 months; and for non-ferrous products, 12 to 24 months. Also in short supply were ball bearings, chains and timber, and, unless deliveries of these commodities keep pace, the rate of output will not respond fully to increased steel deliveries. Broadly, an all-round improvement in the supply position is likely during

1948, but on present showing it is the iron-casting position that may be expected to remain the most serious bottleneck.

Certainly, the development plans already announced by the industry will readily absorb any increased supplies that do, in fact, materialise. Ford production plans for up to 300 tractors a day have been in existence for some time, and the new factory at Dagenham is reported to be making good progress. The Standard Motor Company long ago announced a target of 500 tractors a day, which could be achieved in the present factory, given full double-shift working and the delivery of a small number of outstanding machine-tool requirements.

Massey-Harris, Limited, an offshoot of the Canadian parent firm of the same name, was established in this country as an importing and assembling agency in 1908, but began manufacturing in England on a small scale in 1945. The range of products includes fertiliser drills, manure spreaders, harrows, hammer mills, mowers and rakes, but the intention is to embark on the production of combine harvesters. To finance this venture, the company issued 400,000*l.* of guaranteed debenture stock early in 1947, and it is expected that the first harvesters will be ready for this year's harvest.

Another significant new issue was that of 400,000*l.* in preference shares by Marshall, Sons and Company, of Gainsborough, in March last. Marshall's are the only British manufacturers of heavy wheeled Diesel tractors in the 40-h.p. class, and, through their acquisition of John Fowler and Company (Leeds), Limited, in January, 1947, became the only manufacturers in this country of agricultural, as distinct from horticultural, crawler tractors. Little has been heard of the crawler project since the merger, but Marshalls' chairman recently announced that a new Marshall-Fowler Mark VF Diesel crawler tractor would become available from the Leeds works this summer. Meanwhile, a prototype was shown and aroused favourable comment at Lincoln last year, and it is understood that John Fowler have ceased the production of industrial engines in order to concentrate on the crawler.

At Doncaster, the International Harvester Company, Limited, are engaged on the development of a site which was acquired at the end of the war, and building there will include a new foundry. Progress has not been as quick as was originally hoped, however, largely because of delays in obtaining building permits, and the Harvester Company are not likely to be in full production before the second half of 1949. The production programme includes a tractor output of about 3,300 machines a year, as well as haymaking machines and combine harvesters. It is also planned eventually to produce a "cub" tractor for use on small farms. During 1947, it was announced that extensions to the Doncaster site, which originally covered 172,200 sq. ft., would total 104,000 sq. ft., of which 48,000 would be for tractor manufacture and 46,000 for a foundry. For the time being, however, manufacture at Doncaster is confined to spare parts for International Harvester products built in the United States and now at work in this country.

TABLE II.—IMPORTS OF AGRICULTURAL MACHINERY, 1938 TO 1947 (£1,000).

	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947 (11 months).
Agricultural tractors	575	1,125	1,461	3,146	1,807	1,229	1,536	761	606	1,093
Other agricultural machinery	550	804	1,725	2,719	2,654	3,245	2,553	220	1,359	3,046
Total	1,125	1,929	3,686	5,865	4,461	4,474	4,089	2,981	1,965	4,139
Weight (tons)	14,995	22,499	39,523	58,050	42,835	39,378	31,857	24,542	15,203	21,325

TABLE III.—UNITED KINGDOM EXPORTS OF AGRICULTURAL MACHINERY, 1938 TO 1947 (£1,000).

	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947 (11 months).
Ploughs	207	158	185	135	133	145	171	435	934	882
Threshers	49	53	52	17	13	22	44	147	385	359
Tractors and parts	621	379	309	37	13	70	283	930	3,414	4,442
All other sorts	410	323	292	198	202	192	296	746	2,066	2,233
Total	1,287	913	838	387	361	429	794	2,258	4,799	7,916
Weight (tons)	18,597	13,059	10,868	4,128	3,712	4,582	7,639	23,990	44,123	51,756

TABLE IV.—U.K. EXPORTS OF AGRICULTURAL MACHINERY BY COUNTRY OF DESTINATION, 1946 AND 1947.

Country.	1946 (11 months).				1947 (11 months).			
	Tractors.		Others.		Tractors.		Others.	
	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*
Eire	1,857	259	3,933	466	3,406	600	4,209	586
South Africa	1,073	170	2,524	263	1,374	235	1,959	277
Australia	2,482	364	—	—	3,090	494	—	—
Other British countries	1,496	275	5,145	548	3,060	560	4,354	679
Finland	2,038	259	—	—	957	121	—	—
Sweden	1,342	200	—	—	1,782	322	—	—
Denmark	1,922	266	950	114	1,355	217	1,534	216
Netherlands	—	—	2,644	219	—	—	2,549	342
Other Foreign countries	9,160	1,327	14,395	1,517	11,463	1,911	10,709	1,375
Total	21,370	3,120	29,591	3,127	26,487	4,460	25,319	3,475

It is of interest to turn next from the changing structure of the industry to changes in the nature of the output. Apart from tractors, the most urgently needed farming equipment in this country is combine harvesting machinery, and potato and beet harvesters. In none of these three lines of development has a fully successful product yet been put on the market. British-made combines are now available in small numbers, but have not yet proved entirely satisfactory. On the whole, the design is thought to be good, but farmers report a disappointingly high number of breakdowns in use, suggesting that there are still a number of structural difficulties to be overcome.

It is well to remember the special difficulties associated with the development of agricultural machinery, which are amply illustrated by the combine harvester. The harvester designer, to be fully successful, must produce a machine which will bring in a crop after all types of summer. The wet downcast corn cut in 1946 and the over-dry harvest of 1947 illustrate extreme conditions. The combine must also operate successfully on all types of land, of which there are many in England, and design is further restricted by such points as the necessity for the finished machine to go through the average farm gate. It is further impossible to test a machine at the prototype stage under all the conditions that the finished product will be called upon to face, and thus it is inevitable that the early types of any new development require substantial modifications.

Combine harvesters in this country are now emerging from the early stages and it may be confidently expected that future development will be rapid. The best-established firm in this particular field are Minneapolis Moline (England) Limited, whose product has a 5-ft. cut and a 4-ft. threshing drum, and is of dimensions which experience to date shows to be well suited to British agriculture. The Minneapolis Moline machine is tractor-hauled, as also is the new 5 ft. 6 in. combine which it is expected will shortly be put on the market by Marshall, Sons and Company, at Gainsborough. Massey-Harris are expected shortly to market a larger self-propelled combine with an 8-ft. cut.

In root harvesting, machinery development is less satisfactory. There are, for example, normally about 400,000 acres of land under sugar beet in this country, the harvesting of which gives rise to one of the biggest labour problems in the agricultural year. A census of agricultural machinery made early in 1946 showed that there were 28,000 sugar-beet lifting ploughs in use, but less than 180 sugar-beet harvesters. The plough does no more than turn the beet out of the earth, leaving it to be picked up by hand. The extent to which beet harvesting has been mechanised, therefore, is indicated by the small number of harvesters which are able to do the complete job of lifting and clearing the beet and depositing it in a sack or truck. Against this, the British Sugar Corporation consider it desirable that the harvesting of the crop should be 35 per cent. to 40 per cent. mechanised, and the pending departure of prisoner of war labour is likely to raise the problem with new urgency. No doubt, there are a few more beet harvesters in existence now than there were in 1946, but the number remains low because the technical difficulties have not yet been solved. Similar problems are involved in potato harvesting, which, like the beet harvest, makes an expensive peak demand on agricultural labour. There were 47,000 potato spinners in use in 1946, but these, like the beet plough, leave the uncovered crop to be picked up by hand. By contrast, there were less than 4,000 potato chain-elevator diggers, and again the small number is indicative of inadequate technical development. Generally, root and tuber harvesters are designed to lift the crop with a plough share and then to pass it over elevator chains, which remove the soil and deposit the crop in bags, or perhaps in a truck running parallel to the harvester. One of the biggest difficulties is to remove the earth and stones without damaging the crop, and, even more than in the case of the combine, the necessity for efficient operation under widely varying soil conditions calls for great versatility in design.

The handling of manure is a third heavy demand on farm labour, and one to which machinery makers have been able to make considerable contributions in recent years; for example, new machinery exhibited at the Royal Show at Lincoln last year included the Wild-Thwaites tractor-drawn farmyard manure spreader, which disintegrates heaps of manure set in fields and spreads it evenly over tilled areas. A second machine, by the same company, was a farmyard manure-loader, which automatically digs manure from a cattle yard and elevates it into a cart. Another Royal Show innovation was the Leverton pea-cutter, which consists of tractor-mounted V knives with dividers, which are propelled in front of the tractor so as to shave the ground of tangled crops, a process which, hitherto, has been difficult even by hand. A recent tractor development of some interest is the system of power steering transmission, designed to increase manœuvrability, in which driving and steering are combined in the rear wheels. This has been developed by Gates and Hardy, Limited, in conjunction with the Lockheed Hydraulic Brake Company, Limited.

The average British farmer, however, is more concerned with the shortages of established types of

farm equipment than with the most recent developments. Despite increased total supplies and a reduced export quota during 1947, there are still long delays in obtaining delivery of many types of machinery and implements; for instance, the shortage of ploughshares was much publicised during the recent autumn ploughing season. The output figures (Table I page 100), show that the supply of horse-drawn ploughs fluctuates considerably, although the output of tractor-drawn ploughs has risen steadily from just under 13,000 a year in 1945 to a rate of 43,000 a year in the third quarter of 1947. In these last figures, the development of "satellite" manufacturers to the tractor builders is evident. The two most recent censuses of agricultural machinery showed that the number of tractor ploughs in use rose from 135,000 in 1944 to 156,000 in 1946, while the horse-drawn ploughs declined slightly from 255,000 to 247,000 in the same period. The National Farmers' Union estimate the life of a tractor plough at 12 years and that of a horse-drawn plough at 15 years, on which basis replacement of the 1946 population would need 13,000 tractor ploughs and 16,500 horse-drawn ploughs a year. This, however, is not the full story, since the tractor plough population is expanding, and the total annual requirements at the moment are probably at least 20,000 a year. The figures also conceal shortages of certain types of ploughs, particularly of heavy multi-furrow ploughs, and of spare ploughshares for replacement. Even so, the rate of output in the third quarter of 1947, if maintained, will insure against a repetition in 1948 of last year's shortages.

The delivery position for tractors themselves has also improved in the latter half of 1947, but is still far from satisfactory from the farmer's point of view. With the exception of the Ferguson tractor, which can be obtained now in a month or less, a buyer must wait at least six months for a Ford tractor and rather longer for the David Brown or Marshall products. There are also long delays in obtaining delivery of imported machinery, notably, crawler tractors, but this position should be eased a little towards the end of 1948 as the Marshall-Fowler crawler comes on the market. Meanwhile, the import figures (shown in the *Trade and Navigation Accounts* and summarised in Table II, page 101) show that deliveries of foreign-built agricultural machinery was at the rate of about 23,000 tons in 1947, as compared with 15,000 tons in 1946 and about the same in 1938. Another shortage of which many farmers complain is that of one-man pick-up hay balers, of which supplies are partly imported and partly built by D. Lorant, Limited, in this country.

The danger of present developments in the industry from the agriculturists' point of view lies in the fact that supplies are not well balanced, and there is no immediate likelihood of balance being restored. Already tractor output has outrun that of tractor implements, and, although this position is already being corrected, there has been no comparable expansion in the output of those machines in which tractor makers have little or no interest; that is, in such machines as combine harvesters, combine drills, binders, balers and mowers. Although, as indicated above, some expansion is afoot in the output of certain of these machines, they are not produced, as yet at least, by mass-production methods, and substantial arrears are likely to continue at least through the current year.

During 1947, however, the home farmer received a slightly higher proportion of the total output of British-made agricultural machinery than he did in 1946. Exports (Table I, page 100) for the first three quarters were valued at 5,273,000*l.*, or slightly less than 20 per cent. of the value of the total output, whereas for 1946 the corresponding figure was 23 per cent. Machinery available for home buyers was then being supplied at the rate of 30,000,000*l.* a year in the period January to September, 1947, as compared with 20,000,000*l.* in 1946. The general level of prices was advanced to 160 per cent. of the 1939 figure in March, 1947, as compared with 150 per cent. during the greater part of 1946. This suggests that the actual rate of supply of machinery during the first three quarters of 1947 was slightly less than 150 per cent. of that in 1946. The volume exported increased slightly during 1947, and Tables III and IV, on page 101, taken from the same source as Table II, show the structure of the export market, both by types of machine exported and by country of destination. Tractors accounted for 56 per cent., by value, of exports in the first eleven months of 1947 and for 50 per cent. by value of the exports in 1946. In 1938, tractors accounted for slightly less than half the value, and, ignoring the war years, there is a tendency for tractor exports to gain in relative importance. This year, the Ferguson order from the United States alone will be sufficient to double last year's tractor export figure, and it is likely that tractors will account for at least 70 per cent. of the year's total exports.

The export destination table shows that Eire was the best customer, both in 1946 and in 1947, and, in the latter year, took about one-seventh of the total of overseas deliveries. Next in order of importance in 1947 were South Africa, Australia, Denmark and the Netherlands. With the exception of the American order, the 1948 export market may be expected to show much the same pattern. In particular, it will be recalled that the trade agreement concluded with Eire towards the end of 1947 made special provision for increased supplies of agricultural machinery, while negotiations with Denmark are likely, if successful, to include similar arrangements.

In conclusion, it is of some interest to consider the relation between the tractor industry and the motor industry. As three of the leading tractor makers (namely, Ford, Standard-Ferguson, and David Brown) are also in the motor industry, the fortunes of the two industries are closely linked. The Standard Vanguard engine, for example, has certain parts in common with that of the Standard-Ferguson tractor engine. These are limited, it is true, to cylinder sleeves, pistons, connecting rods and crankshafts, but the remaining parts, although different, are produced by the same machine tools and similar tooling. Certain management and other overheads are common to both products and cost structures, therefore, are inter-dependent to some extent. In particular, a bad setback in the export market for either tractors or cars could be expected to have adverse results on the cost position of the other. From this point of view, the future of the tractor industry assumes a wider importance and 1948 will be a very significant year.

At the present rate of tractor production, estimated to be about 120,000 a year, there would be something like 80,000 tractors to be sold overseas, and, if the tractor builders' development plans progress satisfactorily, the actual exportable surplus during 1948 will, in fact, be still larger. Critics of the industry have expressed doubts whether the tractors now being built in this country for export are of the right type and horse-power to capture permanently a large share of the overseas market. To this question no one, as yet, knows the answer, and there is no profit in speculation at the moment; 1948 trading experience, however, will provide a large part of the answer, and the movements of tractor export figures in the coming months will provide an index to the future prosperity of the industry.

SEVENTH INTERNATIONAL CONGRESS OF APPLIED MECHANICS.—Preliminary information regarding the Seventh International Congress of Applied Mechanics has just been issued. It will be held at the Imperial College of Science and Technology, South Kensington, London, S.W.7, from September 5 to 11, 1948. The technical sessions will be organised under four sections, namely (*a*) elasticity and plasticity; (*b*) aerodynamics, hydrodynamics and meteorology; (*c*) thermodynamics and heat transfer, and (4) vibration, lubrication and experimental methods. In addition, some ten general lectures or surveys, on subjects likely to be of interest to members, are contemplated. Arrangements have been made for visits to the National Physical Laboratory, the Royal Aircraft Establishment, the National Gas Turbine Establishment, and the General Electric Company's research laboratories, during the week following the Congress. Forms of application for membership and further information may be obtained on application to the organising secretary of the Congress, Imperial College, at the address given above.

APPRENTICE-TRAINING SCHOOL; DERBY LOCOMOTIVE WORKS.

IN the past 25 years, the training of pupils, engineering apprentices, and trade apprentices in locomotive works has been materially improved. They have been placed in the shops, and moved from job to job, according to a predetermined scheme; and those without a university education have been given the opportunity, and encouraged, to undertake part-time study. Nevertheless, it is doubtful whether full use was generally made of the several years of a trainee's time; in particular, many trade apprentices undoubtedly reached their majority without having fully comprehended and mastered the basic principles and technique of their craft. Much depended on whether or not the apprentice was fortunate in working with a craftsman who, under a piece-work system, was prepared to devote some of his time to imparting his knowledge and skill. It is therefore of interest to record the establishment of an apprentices training school at Derby locomotive works (now in the London Midland Region of British Railways), which is intended to rectify this deficiency by providing for a year of study and practical work before the apprentice enters the production shops. The school was planned by the Chief Mechanical Engineer of the London Midland and Scottish Railway Company, Mr. H. G. Ivatt, and his staff assistant, Mr. E. J. Larkin, and the principal is Mr. Harold Thomas. It has been in use since April, 1947, but was formally opened on December 4, 1947, by Sir Robert Burrows, chairman of the company.

There are seven main works which come under the Chief Mechanical Engineer's department. The first training school has been opened at Derby, and when experience has been gained, it is hoped to establish schools at some of the other works. The C.M.E.'s department employs over 45,000 persons, and it is necessary to engage more than 700 apprentices per annum. Derby locomotive works employs 4,280 persons, of whom 525 are apprentices. Trainees in the main works are of three types: pupils, engineering apprentices, and trade apprentices. The number of pupils is relatively small; they must have obtained a university degree in engineering, are selected entirely on merit, and their age on starting the one or two years' course must generally be between 21 and 24. Engineering apprentices start between 16 and 18 years of age, and pass through all the principal shops before the age of 21. They attend part-time classes to gain a Higher National Certificate or a Degree, and they are paid the same rates of pay as trade apprentices. Each year, half of the vacancies for engineering apprentices are filled by the most promising trade apprentices.

All apprentices are moved from one job to another according to the progressive system of workshop training, which was introduced in the L.M.S. in 1932, and all receive ample opportunities. The period which each apprentice spends in a particular section of a shop is fixed, and depends on the number of apprentices required in each section, the relationship of this number to the total number of apprentices in the shop, and the total time to be spent in the shop, having regard to the relative training value of the work. The scheme is readily implemented, but requires reviewing periodically. The foremen report on apprentices passing through their sections, with particular reference to ability and attention to duties. The principal aims of the school are: "To introduce the boy to new conditions; to acquaint him with the necessity for adapting himself to a new environment; to give definite and systematic training in manual skill; to ascertain the boy's natural aptitude, and thus try to place him in a trade in which he is considered likely to be successful; to give class instruction in allied subjects, and so widen the field of knowledge and general outlook on life; and to give the boy every encouragement to develop into a useful citizen."

A general view of the school workshop is given in Fig. 1, opposite. The accommodation and equipment are based on three principles: (1) that the number of trainees is a fifth of the total number of apprentices in the works (boys normally enter the school at 15 years of age, and always leave for the shops at 16); (2) that the trainees are started at four-monthly intervals (the number started is therefore approximately a third of the total number in the school); and (3) that two-thirds of the time available is devoted to practical work, and one-third to classroom work. There is accommodation for 100 trainees, and the normal intake is 30 every four months. On the practical side, the first four months of a trainee's year in the school are probationary, and are devoted to preliminary training in all sections of the workshop. If found satisfactory, the trainee spends the remaining eight months in that section of the workshop which covers the trade to which he is to be apprenticed. It has been possible to group the 18 trades employed in the shops into six sections; and, according to his future trade, a trainee receives his eight months' practical training in the appropriate section. The

SCHOOL FOR RAILWAY APPRENTICES, DERBY.

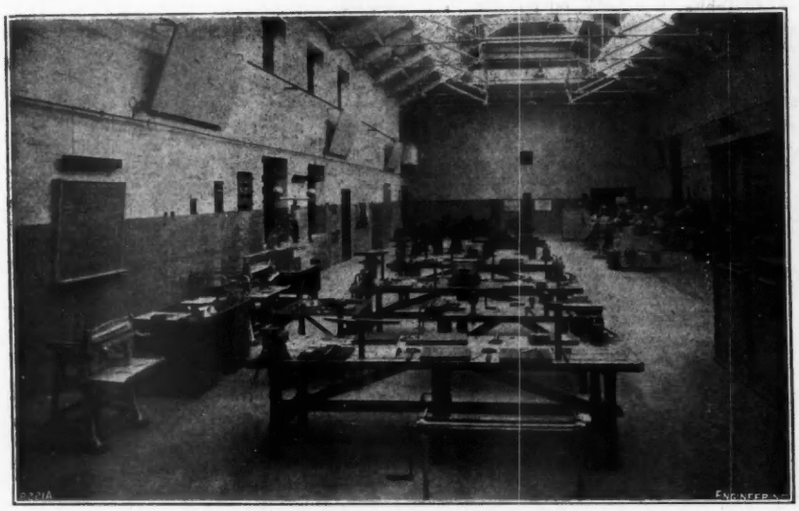


FIG. 1. TRAINING-SCHOOL WORKSHOP.

FIG. 2. MACHINE SECTION.

six sections are: joinery and pattern-making; moulding and casting; smithing and forging; plate and sheet-metal work; turning and machining; and fitting and assembling. At the end of the probationary four months, the chief instructor, who is responsible to the works superintendent, decides the trade to which each trainee is to be apprenticed. This will depend, to some extent, on the requirements of the works, but in general every effort is made to fit a boy into the trade for which he seems most suited. A 44-hour week is worked in the main shops at Derby, but the school hours provide for a 38¾-hour week to make the change from day school to the works gradual. During the latter eight months of training, the section instructors submit weekly assessments of each boy's progress, expressed in "points"; and a small bonus, based on the total points awarded, is paid as an incentive, in addition to the standard wage.

All trainees follow the same course of theoretical training, which is complementary to the National Certificate and Degree courses provided by Derby Technical College. The curriculum includes subjects which it is anticipated will be provided by the County Colleges to be established under the Education Act, 1944. The subjects taken, and the hours allotted per week are as follows: workshop mathematics, 3; workshop science, 3; workshop theory, 1½; free-hand sketching and machine drawing, 1½; industrial history, ¾; geography, ¾; "individual expression," ¾; "school diary," ¾. The total hours per week on theoretical work are 12. "Individual expression" denotes training as an individual rather than as a craftsman, and includes the ability to make clear written or spoken statements. "School diary" denotes time spent on writing up the work of the week, and is regarded as a useful means of training, and of assessing the practical value of the instruction. Sketching and drawing, industrial history, and workshop theory are taught by members of the railway staff. Lecturers from the Derby Technical College take the four other subjects, and they come from the college to the training school for this purpose. This is regarded as a novel arrangement, as it is customary for part-time students to be given time off from a works to attend the local technical college. The new practice was arranged in co-operation with the Ministry of Education and the Derby Education Committee. It is undoubtedly advantageous from most points of view; less time is wasted, and discipline is more easily maintained. The syllabus of the school also includes one hour each week for physical training, talks by members of the railway staff, and visits to works.

The building which houses the school is over 100 years old, but alterations have been carried out to adapt it for its purpose. The floor area is 4,720 sq. ft. In addition to the workshop (Fig. 1), there are two lecture rooms and administrative offices. The plate and sheet-metal work section is shown in the foreground of Fig. 1, the fitting and assembling section is in the left background, and the machine section, in the right background, is also shown in Fig. 2. There are also sections for the other practical subjects which are taught. The majority of the articles made by the trainees are tools for their own use, but some parts for the main works are also made. A high standard of fitting is achieved in a few months of training.

75-B.H.P. DIESEL-ENGINED GOODS VEHICLES.

DURING the recent war, the manufacturing facilities of Leyland Motors Limited, Leyland, Lancashire, were occupied solely with the production of armoured fighting vehicles and for some three years no wheeled vehicles of any description were manufactured by the firm. When the war ended, therefore, they were in a position to re-orientate both their manufacturing and selling policies and to bring out new models if desired. Previously, it had been the policy of the firm to build primarily for the home market an adapt these vehicles to meet overseas conditions; only rarely were vehicles designed basically for export. This pre-war policy has now been altered and the company now design and build separate vehicles for the overseas markets in addition to vehicles for the home market. Post-war investigations have shown that there is a demand overseas for a medium capacity vehicle, preferably fitted with a Diesel engine, and in order to meet this demand, Leyland Motors have produced an entirely new vehicle which has been designated the Comet.

The Comet is essentially an export model, having been designed specifically to meet overseas conditions. The maximum load-carrying capacity is between 6 and 7 tons on the two-axle models, and three different chassis are available, namely, a general-purpose type having a wheelbase of 14 ft. 2 in., a tipper having a wheelbase of 10 ft. 5 in., and a tractor for use with semi-articulated trailers, the wheelbase in this case being 9 ft. 2 in. The general-purpose chassis is illustrated in Fig. 1, on page 104, and it will be noted that it is of simple but rugged design. The chassis shown is fitted with left-hand steering, but all three models are available with either left- or right-hand steering. In addition to the range of goods vehicles, Leyland Motors have arranged for the production of a passenger chassis which will use existing Comet components as far as possible; this chassis, however, will not be available until later.

With the exception of the chassis frame, the three different types of goods vehicle basically are the same. A six-cylinder direct-injection compression-ignition oil engine is fitted having a bore and stroke of 3·8 in. and 4·5 in., respectively. The engine is illustrated in Fig. 3, on page 104, while the performance curves are shown in Fig. 2, from which it will be seen that the maximum output is 75 brake horse-power at 2,000 r.p.m., and the maximum torque 220 lb.-ft. at 1,100 r.p.m. The engine, clutch and gearbox are of unit construction and are carried in the frame by a rubber-insulated mounting at the front end and by a banjo-type cross-member at the rear. The crankcase and cylinders are in the form of a monobloc casting, and the cylinders are fitted with dry-type liners which are a push fit in the cylinder bores. The bores of the liners are finished before they are fitted in the cylinders and they are located by flanges formed on their upper ends which fit into recesses machined in the cylinder bores. The cylinder head is a single iron casting, and it is fitted with overhead valves operated in the usual manner through push rods and rocking levers. Detachable Stellite-faced inlet- and exhaust-valve seats are used and these are fitted into machined recesses by the freezing process. The valves, like the valve seats, also are faced with Stellite and, in addition, the valve stems are chromium flashed so as to minimise wear. The crankshaft is a steel forging hardened by the nitriding process; it is carried in seven thin-shell indium-coated copper-lead bearings, and is located longitudinally from the centre bearing by thrust washers. The journals and crankpins have diameters of 2·9 in. and 2·4 in., respectively, the latter being drilled eccentrically, so as to reduce centrifugal loading and at the same time act as sludge traps. Drilled oilways are provided for pressure lubrication to all bearings and a torsional-vibration damper of the rubber-bonded type is fitted externally at the front end. The pistons are of aluminium alloy and each is fitted with three wedge-section compression rings, one step-type scraper ring, and one slotted oil-control ring; provision is made, however, for the fitting of a further oil-control ring on the skirt when required. The combustion chambers are machined in the heads of the pistons and are of toroidal form.

The camshaft is a steel forging with integral cams and is located on the right-hand side of the crankcase; it runs in four bearings and is driven from the front end of the crankshaft through helical gears. All bearings within the engine are pressure lubricated, the oil being supplied by a gear-type pump situated in the sump and driven through spiral gears from the centre of the camshaft. The oil is drawn from the sump through a floating strainer and before entering the system passes through an external filter of the full-flow pattern, but in order to prevent damage due to possible choking of the filter, a by-pass pipe is provided. Engine cooling is assisted by a centrifugal pump and a four-bladed fan fitted to the front of the engine and driven at 1·5 times the engine speed by a

75-B.H.P. DIESEL-ENGINED GOODS VEHICLE.

LEYLAND MOTORS, LIMITED, LEYLAND, LANCASHIRE.

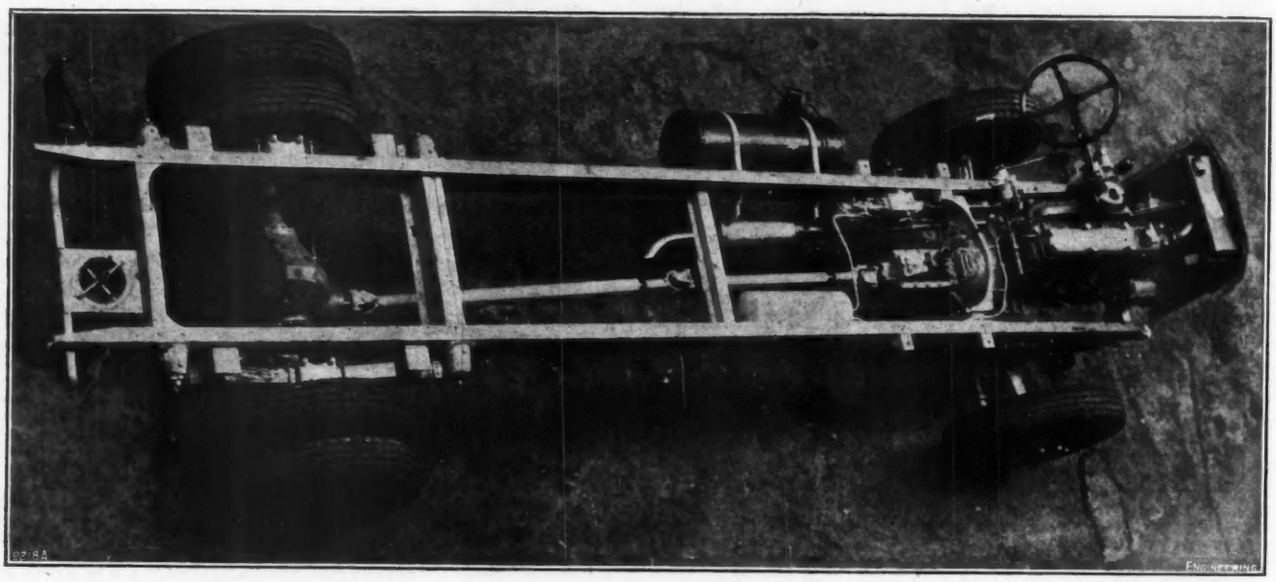
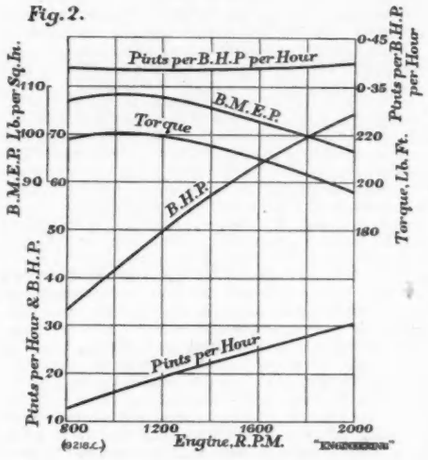


FIG. 1. LONG-WHEELBASE CHASSIS.

Fig. 2.



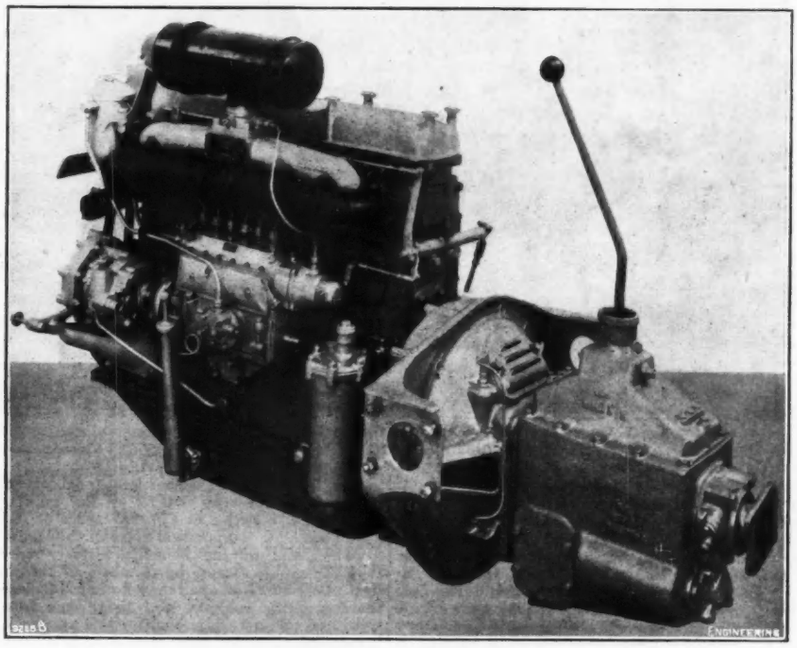


FIG. 3. ENGINE, CLUTCH AND GEARBOX.

single V belt. The radiator is fitted to the forward engine bearers and is of the Still-tube type, each tube of which can be removed easily.

The injection equipment consists of a C.A.V. fuel pump which is used in conjunction with Leyland-type multi-hole injectors. A vacuum-type governor is fitted which stabilises the engine idling speed at approximately 350 r.p.m. and controls the maximum speed at 2,000 r.p.m. The vacuum is created by a Venturi tube situated in the induction manifold, the butterfly valve of which is operated by the accelerator pedal. The exhauster for the vacuum-braking system can be seen in Fig. 3, immediately in front of the injection pump; the exhauster is of the sliding-vane type and draws its own supply of lubricant from the engine sump. Other auxiliaries include the starter motor and the dynamo, both of which are fitted to the right-hand side of the engine, the dynamo being belt driven in tandem with the water pump and fan assembly. The 24-volt system is used throughout, and special attention has been paid to the electrical circuits; these are in the form of detachable harnesses carried in P.V.C. tubing, and three plugs and sockets connect all circuits to the switchboard.

Although the standard vehicle is fitted with an oil engine, a 100-brake horse-power petrol engine can be supplied as an alternative. The basic design of the petrol engine, however, is similar to that of the oil engine, but the output, naturally, is higher, the petrol engine developing 86 brake horse-power at 2,000 r.p.m. and 100 brake horse-power at 2,480 r.p.m.

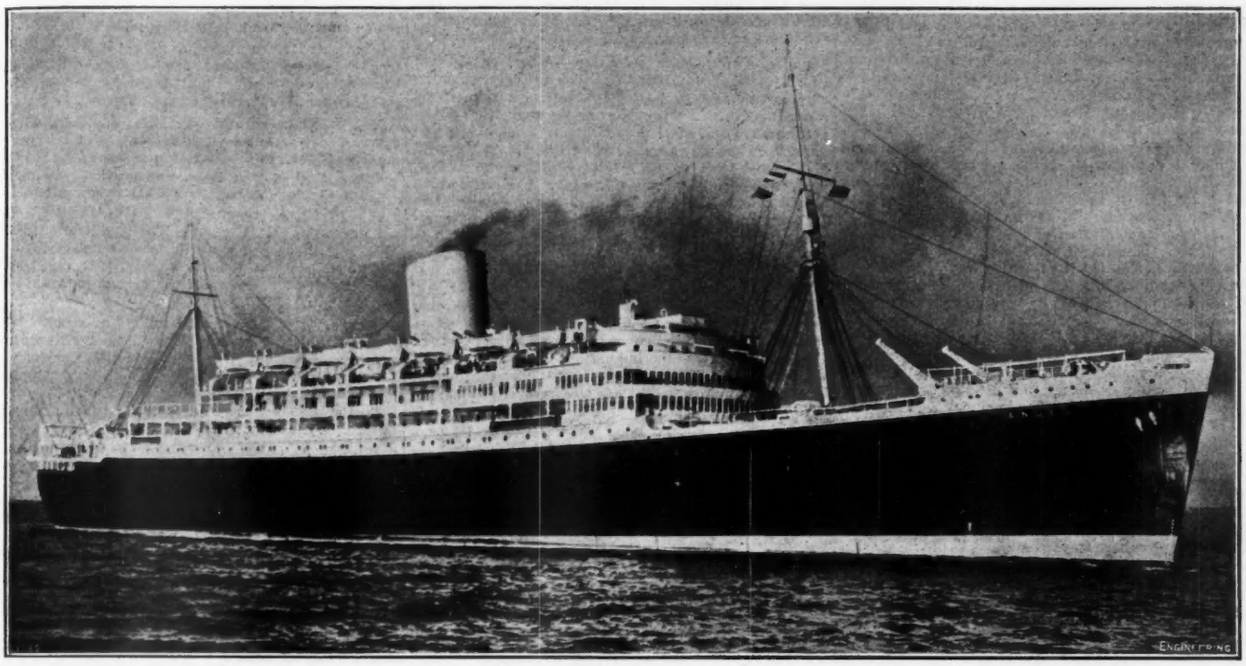
As pointed out previously, the engine, clutch and gearbox form a single unit. The clutch is of the single dry-plate type, the liners of which are slotted radially, which, in conjunction with holes drilled radially in the periphery of the flywheel, ensures adequate cooling of the working surfaces. The three clutch-withdrawal levers are carried by needle-roller bearings, and the pressure pads which engage with the outer ends of the levers are arranged so that they can be reversed, thus providing adjustment for wear. The gearbox has five forward speeds and one reverse speed. Helical gear wheels are employed throughout, the top, fourth and third speed gear wheels being in constant mesh, while the second and first gear wheels slide on helical splines. Provision has been made for the fitting of a power take-off, and on the tipping model this is standard. The ratios are: top 1 to 1, fourth 1·55 to 1, third 2·49 to 1, second 4·21 to 1, first 7·12 to 1, and reverse 7·45 to 1.

The drive from the gearbox is transmitted through open tubular-type propeller shafts fitted with Hardy Spicer needle-roller universal joints. The rear axle is of built-up construction and consists of a cast-steel differential housing with two forged-steel axle tubes spigoted into the casing and held thereto by flanges and studs. Final drive is through a hypoid bevel and pinion which gives a reduction of 6·16 to 1, but alternative ratios are available, namely, 5·43 to 1 and 6·8 to 1. An outrigger bearing is fitted to the pinion shaft and the ball races are pre-loaded so as to minimise deflection under load. A standard bevel-type differential gear is provided, and the wheel hubs are carried by opposed taper-roller bearings in the usual manner. The front axle is a solid-steel forging of I-section, the king pins being fitted in tapered holes formed in the axle beam; the hubs, like the rear axle, are fitted with opposed taper-roller bearings.

The chassis frame is of straightforward design, the side members being channel-section carbon-steel pressings having a maximum section of 9 in. by 3 in.; the material is ¼ in. in thickness. The long-wheelbase model is provided with five cross-members, while the

S.S. "ANDES"; ROYAL MAIL LINES.

MESSRS. HARLAND AND WOLFF, LIMITED, BELFAST.



tipper and tractor types have four; in each case the cross-members are bolted in position, but in order to give maximum rigidity, the forward cross-member is spigoted into brackets bolted to the front of the chassis-frame side members. The springs are of the laminated semi-elliptical pattern and the leaves are shot blasted on the tension sides and the edges so as to increase their resistance to fatigue. Marles double cam-and-roller type steering gear is fitted, the steering box being bolted directly to the top of the frame side member. The steering-box ratio is approximately 24·7 to 1, and the turning circle is about 60 ft. for the general-purpose model; on the tipper and tractor models the turning circles are, of course, less, being 45 ft. and 40 ft., respectively. The brakes are of the internal-expanding type, operating on all four wheels, and are fitted with two leading shoes, which are expanded by wedges. The footbrake is vacuum assisted and operates hydraulically on all four wheels, the master cylinder of the hydraulic system being integral with a Clayton-Dewandre vacuum-servo unit. The front brakes are actuated directly by hydraulic cylinders fitted to each wheel, but the rear brakes are connected through rods and a bell-crank lever to a single cylinder fitted to the rear-axle casing, this arrangement simplifying the mechanical linkage for the hand brake which operates on the rear wheels only. Detachable steel-disc wheels having three piece rims are used and these are fitted with 9 in. by 20 in. tyres; twin wheels are fitted to the rear axle.

In the design of the cab and bonnet, Leyland Motors have made a distinct departure from their usual practice, in that they have dispensed with their usual radiator in favour of a concealed type, the bonnet sweeping down over, and completely enclosing, the radiator, suitable slots being provided in the bonnet front for the admission of cooling air. The cab is of the semi-forward-control type, this design offering the best compromise between platform length, weight distribution, engine accessibility, etc. Accessibility, however, has not been sacrified, and the manufacturers claim that a major overhaul can be carried out without removing the engine from the chassis. At present, the Comet is intended for export only.

DISPLAY OF PAINT AND FINISHING TECHNIQUES.—On Monday, January 26, 1948, the Secretary for Overseas Trade, Mr. A. G. Bottomley, O.B.E., M.P., opened, at Charing Cross Hotel, an exhibition arranged to help British manufacturers to select durable and pleasing finishes for the goods being prepared for export. The exhibition, which will remain open until 6 p.m. on Saturday, January 31, has been organised by the Paints Division of Imperial Chemical Industries, Limited, and includes examples of suitable paints and finishes for machinery parts, castings, car bodies, domestic ware, etc.

ROYAL MAIL LINES S.S. "ANDES."

As briefly recorded on page 87 of our last week's issue, the latest addition to the fleet of the Royal Mail Lines, Limited, the twin-screw liner Andes, sailed on her maiden voyage to South America on Thursday, January 22. Actually, this vessel was completed at the outbreak of war, but instead of entering the South American service, all the internal furnishings were removed and she was fitted out as a troopship, in which capacity she steamed over half-a-million nautical miles and carried some 350,000 troops. Recently, the vessel was handed back to her owners, and the work of reconditioning was undertaken by the original builders, Messrs. Harland and Wolff, Limited. The time taken to complete this work was ten months and in view of her original furnishings having been destroyed by enemy action while in store, this represents a creditable achievement. Originally, the Andes was intended to carry 600 passengers, but this number was reduced so that additional space could be allocated to the crew's accommodation, and she can now accommodate 528 passengers; 324 first-class and 204 third-class.

A photograph of the Andes is reproduced on this page, from which it will be seen that the raked and rounded stem and cruiser stern, together with the well-balanced superstructure and rounded bridge front, combine to give the vessel a graceful appearance. The service speed is 21½ knots, although during her trials a speed of 23 knots was recorded. The overall length is 669 ft. and the length between perpendiculars 630 ft., while the moulded breadth and depth are 83 ft. and 47 ft. 6 in., respectively. There are four complete decks which, commencing with the lowest, are designated A, B, C and D, respectively. In addition, there is a forecastle deck, a lower promenade deck E, an upper promenade deck F and the boat deck, while lower and orlop decks extend forward and aft from the machinery space. The hull is divided into 12 compartments by 11 watertight bulkheads which, with the exception of the forepeak bulkhead, extend upwards to B deck, the forepeak bulkhead extending to C deck. There is a continuous double bottom arranged for the storage of fresh water, water ballast and oil fuel, the forepeak and afterpeak tanks being arranged for the storage of fresh water and oil fuel or water ballast, respectively. Deep fresh-water tanks are arranged in No. 1 hold and deep oil-fuel tanks are situated across the vessel between the forward end of the machinery space and No. 3 hold.

The main propelling machinery consists of a two-shaft arrangement of Parsons-type triple-expansion single-reduction geared turbines. The turbines were manufactured by the builders, and have been designed for a total output of 30,000 shaft horse-power with a steam pressure of 375 lb. per square inch gauge and a steam temperature of 700 deg. F. at the manœuvring valves. A high-pressure astern turbine is incorporated within each intermediate-pressure ahead casing, and the high-pressure astern turbines exhaust into low-pressure astern turbines incorporated within the low-pressure ahead casings. End-tightened blading is fitted to the high-pressure and intermediate-pressure ahead turbines, and to make this possible the high-pressure astern turbine has been designed so that the direction of thrust is constant regardless of the direction of travel. The ahead turbines are of all-reaction design, while the high-pressure astern turbine consists of an impulse wheel; the low-pressure astern turbine, however, is of the impulse-reaction type. The casings for the high-pressure and intermediate-pressure ahead turbines, and the high-pressure astern turbines, are of cast steel and all turbine casings are rigidly bolted to the gear-case, while at the forward end they are supported by cast-iron pedestals which extend from the top of the main seatings to the bearing supports. The reduction gearing is of the double-helical type, the gear wheels having been cut by the builders.

The main condensers are of the underslung two-flow Weir regenerative type. Each condenser has a cooling surface of approximately 14,000 sq. ft., and they are capable of maintaining a steady vacuum of 27½ in. when the sea temperature is 85 deg. F. and the turbines are developing their maximum designed power. The condensers are constructed from mild steel and are fitted with cast-iron water boxes and end covers. The tube plates are of rolled naval brass having a thickness of 1½ in. while the tubes, which are of aluminium-bronze, have an external diameter of ¾ in. Large condensate wells are situated in the bottoms of the condensers and these serve to absorb the fluctuations in boiler-feed demand and to accommodate the floats for the closed-feed controllers.

Steam for the turbines is supplied by three Babcock-Johnson boilers arranged abreast in a separate stokehold. The stokehold is separated from the engine room by a watertight bulkhead which also serves to carry the feed heaters, separators, steam pipes, etc. The aggregate generating surface of the boilers is 33,735 sq. ft., while the aggregate superheater surface is 10,110 sq. ft., and the boilers have been designed to withstand a working pressure of 485 lb. per square inch; the normal working pressure at the superheater outlet, however, is not more than 425 lb. per square inch. The designed superheat temperature is 750 deg. F., but the working temperature under ordinary conditions is 700 deg. F. The steam and water drums are of solid-forged construction, machined all over, the material being Siemens acid open-hearth mild steel having a tensile strength of 34 to 38 tons per square inch. The superheaters are located on one side of each boiler and arrangements have been made so that, when the maximum superheat is not required, a proportion of the gases can be deflected from them.

There are four main feed pumps, two working and two standby, and these are of the Weir turbine-driven two-stage centrifugal type, while the feed regulator is Messrs. Weir's Robot type. The feed water is heated in three feed heaters arranged in series. The low-pressure heater has a surface of 900 sq. ft., and by using steam at atmospheric pressure led from the main turbines, the temperature of the feed water is raised from 129 deg. F. to 186 deg. F. The intermediate heater has a surface of approximately 820 sq. ft. and raises the temperature of the feed water to 280 deg. F., while the high-pressure heater, which has a surface of about 670 sq. ft., raises the temperature to 350 deg. F. The steam for both the intermediate and high-pressure heaters is bled from the main turbines at pressures of 82 lb. and 198 lb. per square inch absolute, respectively, and the high-pressure heater drains are led to the intermediate heater and the drains from the intermediate heater are, in turn, led to the low-pressure heater.

Each boiler is provided with both forced and induced draught fans, and the combustion air is heated by three Ljungstrom-Howden preheaters, one for each boiler. Fuel oil is supplied by two separate units, each of which is capable of supplying all the boilers when the turbines are developing the normal designed power. The units comprise an electrically-driven oil-fuel pressure pump, a suction filter, a heater and a discharge filter, and each pressure pump is capable of delivering approximately 10 tons of fuel an hour against a pressure of 175 lb. per square inch. Three soot collectors of the Howden-Vortex wet type are provided, one for each boiler, and these are situated above the induced-draught fans. Steam for the auxiliary services is provided by a single-ended air-jacketed Howden-Johnson boiler, which is situated in the stokehold aft of the main boilers. It has been constructed for a working pressure of 200 lb. per square inch gauge and is provided with its own oil-fuel burning installation, forced and induced draught fans, tubular-type air heater and soot collector.

The electric generators are housed in a compartment forward of the stokehold and divided therefrom by a watertight bulkhead. Altogether there are five sets, comprising three turbo generators, each with an output of 1,000 kW at 220 volts, and two Diesel sets, each of which has an output of 500 kW. The generators of the turbo sets are driven through double-reduction gearing, the turbine and generator speeds being 6,500 r.p.m. and 500 r.p.m., respectively. The units are self-contained and include surface condensing plant complete with ejectors, circulating and extraction pumps and Auto-Klean filters. The steam connections are made to all the main boilers, the pressure at the turbine stop valves being 375 lb. to 400 lb. per square inch gauge and the temperature 700 deg. F., but steam can be supplied by the auxiliary boiler. The Diesel generators are of the two-cycle single-acting type.

All the passengers are accommodated in outside cabins and every first-class cabin has either a private bathroom or a shower adjoining. The first-class dining saloon is situated on "B" deck forward, and can accommodate all the first-class passengers at a single sitting. The saloon is air-conditioned and the centre portion has been taken up to the ceiling height of the deck above. A large lounge, known as the grand hall, is located on the upper promenade deck and this has been designed so that it can be converted either into a cinema or a theatre, while immediately forward of the grand hall is an observation lounge which gives views to port and starboard, as well as forward. The first-class smokeroom is aft of the grand hall, the writing room and the library being situated between them to port and starboard, respectively. A cocktail bar and lounge is provided on the after end of the lower promenade deck, while aft of the cocktail bar is an open swimming pool situated in the middle of an open-air café.

In addition to the 528 passengers, the Andes can carry 3,330 tons of refrigerated cargo and 4,648 tons of general cargo, there being three cargo holds forward of the machinery spaces and two aft. Some of the refrigerated spaces are cooled by air-coolers and the remainder by brine grids, the refrigerating plant having been supplied by Messrs. J. and E. Hall, Limited, Dartford, Kent. The cargo hatches to numbers 1, 4 and 5 spaces are served by electric cranes, while numbers 2 and 3 spaces are served by tubular-type steel derricks operated by electric winches.

Generally, the Andes is well fitted out, the comprehensive navigational equipment including radar, directional wireless, and an echo-sounder. A gyro compass is provided, and this controls an automatic helmsman; the steering gear is of the electro-hydraulic type controlled by telemotor from the bridge. Fire-protection arrangements include the Lux-Rich fire-detecting and extinguishing system for the holds, while the Grinnell sprinkler system is fitted throughout the passenger accommodation. The life-saving equipment includes ten 30-ft. and two 24-ft. lifeboats, all of which are fitted with Fleming hand-propelling gear; in addition two 30-ft. motor lifeboats are carried.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Pottery-Firing Ovens and Kilns.—A further addition to the series of standard test codes for fuel-consuming equipment has been issued by the Institution. This code, B.S. No. 1388, provides for the evaluation of the performance and efficiency of intermittent ovens and kilns and continuous tunnel kilns, firing clay, "glost" and enamel ware, and using solid, liquid or gaseous fuel, or electricity as the means of heating. The code, which covers a comprehensive test and a less detailed test for commercial purposes, is in two parts dealing, respectively, with intermittent ovens and kilns and with continuous tunnel kilns. Each part contains sections dealing with general information and design data, test conditions, mean observations from log sheets and preliminary deductions, thermal statements regarding input and output, and kiln performances including thermal efficiency, fuel consumption and other factors. The methods of conducting various tests are contained in appendices. The code extends to 123 pages and is bound in limp cloth. [Price 12*s.* 6*d.*, postage included.]

Fuel Oils for Burners.—A revision of specification B.S. No. 742, covering three categories of fuel oil for burners has been issued. The three categories are intended, respectively, for domestic installations, for marine installations and for general industrial use. These three categories are subdivided into eight classes, lettered from A to H, and the specification contains information on the application of these classes of oils and on points which must be borne in mind by users of the oils. The properties required for each class are specified, and full descriptions of the methods of test are given in the appendices. [Price 6*s.*, postage included.]

Battery Connectors for Electric Vehicles.—Some years ago a specification for the plugs and sockets to be used for the charging of the batteries of battery-driven electric vehicles was published by the Institution. A second specification for a component relating to this type of vehicle has now been published. This, B.S. No. 1412, covers battery connectors, namely, the fittings which form the means of attaching the flexible cable connection to the battery. The fittings are capable of carrying the current normally imposed on the batteries of electric vehicles, up to 400 ampere-hours capacity at the standard five-hour rate. The batteries dealt with in this specification are of the lead-acid type and the dimensions of the fittings, the materials to be used in their manufacture and the method of marking the polarity on the fitting, are prescribed. [Price 2*s.*, postage included.]

BOOKS RECEIVED.

The Directory of Shipowners, Shipbuilders and Marine Engineers, 1948. Compiled under the direction of the Editor of the *Shipbuilding and Shipping Record*. The Directory Publishing Company, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 30*s.* net.]

Daimler, 1896-1946. *A Record of Fifty Years of The Daimler Company*. By ST. JOHN C. NIXON. G. T. Foulis and Company, Limited, 7, Milford-lane, Strand, London, W.C.2. [Price 42*s.*]

The Aluminium Development Association. Information Bulletin No. 13. *Surface Finishing of Aluminium and Its Alloys*. Offices of the Association, 33, Grosvenor-street, London, W.1. [Price 1*s.*]

High Frequency Measuring Techniques Using Transmission Lines. By E. N. PHILLIPS, W. G. STERNS and N. J. GAMARA. John F. Rider Publisher, Incorporated, 404, Fourth-avenue, New York 16, U.S.A. [Price 1·50 dols.]

United States National Bureau of Standards. Miscellaneous Publication No. M187. *Directory of Commercial and College Laboratories*. Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 30 cents.]

Plastics: Theory and Practice. The Technology of High Polymers. By PROFESSOR CHARLES C. WINDING and R. LEONARD HASCHE. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 3·50 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 21*s.*]

Cours de Mécanique. By PROFESSOR HENRY FAVRE. Volume I. *Statique*. Dunod, 92, rue Bonaparte, Paris (VIe.). Leemann Frères, Stockerstrasse 64, Zürich 2.

Steel Files: Their Manufacture and Application. By ERIC N. SIMONS. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 15*s.* net.]

PERSONAL.

MR. H. P. R. SCOTT, who was Director for Steel Castings, Ministry of Supply, Iron and Steel Control, during the latter part of the recent war, has been appointed joint managing director of Messrs. Thomas Summerson and Sons, Limited, and of Messrs. Summerson's Foundries, Limited, Darlington.

MR. J. A. OSBORN, who has occupied the position of technical adviser, steam-turbine department, in the English Electric Company Limited, Queen's House, Kingsway, London, W.C.2, for the past 16 years has retired.

MR. F. NEIL SUTHERLAND, M.A., M.I.E.E., who, as stated on page 82 *ante*, has been appointed general manager of Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex, was previously managing director of the English Electric Company, Limited, in South Africa. He left Johannesburg in December, 1947.

MR. H. W. H. RICHARDS, M.I.C.E., M.I.Mech.E., M.I.E.E., who was appointed electrical engineer, London and North Eastern Railway in May, 1924, and became Chief Electrical Engineer of the system in April, 1941, has now retired.

MR. A. T. ROBERSON, planning manager of the Dunlop Rubber Company, Limited, has been appointed factory manager (non-resident) of St. Mary's Mills, Leicester, and chief planner for the Fort Dunlop group of factories, at Fort Dunlop, Stoke, Thornliebank and Leicester. He will be succeeded as planning manager by MR. G. H. WAY.

MR. M. A. CAMERON, formerly assistant passenger manager, Southern Area, London and North Eastern Railway, has been appointed assistant secretary (traffic) British Transport Commission. Another appointment is that of MR. H. J. BIRKBECK, formerly assistant to MR. A. E. SEWELL, for Road-Rail Central Conference matters. Mr. Birkbeck is now to be assistant (railway and general) to the charges adviser.

MONSANTO CHEMICALS LIMITED, Victoria Station House, London, S.W.1 have announced the formation of a Central Engineering Department under MR. W. M. COOPER, manager of engineering, to be located in London. There will be four divisions, namely, chemical engineering, mechanical engineering, civil engineering, and construction engineering. MR. M. BUIS, B.Sc., will be head of the chemical-engineering division and DR. J. A. GARDNER, A.R.C.Sc., A.R.I.C., will be assistant chief chemical engineer at Ruabon. MR. O. W. MURRAY, M.A. (Cantab.), M.I.Mech.E., M.I.Chem.E., will be chief mechanical engineer, and MR. R. ADAMS, B.Sc., A.M.I.Mech.E., A.M.I.Chem.E., chief civil engineer. MR. J. M. KERSHAW, B.Sc., F.R.I.C., A.M.I.Chem.E., will be assistant to the manager of engineering while continuing to act as chief construction engineer at Newport, where the firm are building a new plant occupying a 125-acre site.

MR. J. ARTHUR REDFERN, J.P., F.I.R.I., for the past 28 years works managing director of Messrs. Redfern's Rubber Works, Limited, Hyde, Cheshire, and chairman since 1941, has retired. He has been succeeded in these two positions by MR. THOMAS H. REDFERN.

MR. W. B. WALLIS, President of the Lectromelt Furnace Corporation, Pittsburgh, Pennsylvania, U.S.A., has been nominated President of the American Foundrymen's Association, 222, W. Adams-street, Chicago, 6, U.S.A., for the 1948-49 session, in succession to MR. M. KUNIANSKY, whose term of office expires in July.

The address of the BRITISH ELECTRICITY AUTHORITY, as from February 1, will be British Electricity House, Great Portland-street, London, W.1. (Telephone: MUSeum 6844; Telegraphic Address, Beeyay Wesdo, London.)

THE PRESS RELATIONS OFFICE of the RAILWAY EXECUTIVE, EASTERN AND NORTH EASTERN REGIONS, formerly that of the London and North Eastern Railway, has been moved from Dorset-square to 11, Blandford-square, London, N.W.1. (Telephone: PADdington 3400—Extensions 35 and 36). The officer in charge, MR. GEORGE DOW, is available for urgent Press calls, after office hours, at PRImrose 7070.

The P.D.N. CASTLE ENGINEERING COMPANY, LIMITED, 87, Pembury-road, Tottenham, London, N.17, have been appointed the London area representatives of MESSRS. J. BATESON LIMITED, Gibraltar Works, Parkinson-lane, Halifax.

MESSRS. VICKERS-ARMSTRONGS LIMITED, Vickers House, Broadway, London, S.W.1, have acquired from AMERICAN TYPE FOUNDERS INCORPORATED, Elizabeth, New Jersey, U.S.A., the sole manufacturing and selling rights, in this and other countries, of the Kelly letter press. These presses will be manufactured at the Vickers-Armstrongs Newcastle-upon-Tyne Works.

The ENGINEERS' GUILD have appointed MESSRS. ARNOLD HILL AND COMPANY to be their secretaries, and all communications should be addressed to the Secretary, The Engineers' Guild, 28, Victoria-street, London, S.W.1. (Telephone: ABBey 6511.) MR. W. A. M. ALLAN, M.I.C.E., continues as honorary secretary.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—There has been a notable increase in steelworks activity since the resumption after the New Year holiday, and, any day now, production should be at the maximum practical capacity of the industry. Both home and export markets have been receiving regularly large tonnages of plates, sections, and bars. The greater part of the increased exports planned for this year, however, are expected to be in more highly fabricated forms than are produced by re-rollers. Semies have been in rather better supply to meet the pressing demands on the rolling mills, while sheetmakers have been obtaining fairly satisfactory tonnages of slabs. Sheet bars have been in short supply, and certain sections of the sheetmaking trade have been working at below full capacity. Substantial orders have been placed for tubes in connection with contracts for petroleum operations in the Near East. Specifications for large tonnages of tube strips, bars, and ingots for various types of tubes have been fully met. So far there has been no diminution in tonnages delivered to shipbuilders. Despite a vigorous campaign for improved scrap collection, the increased tonnages forthcoming so far have not been quite up to expectations. This has given added importance to blast-furnace production, recently augmented by the new unit at Tollcross Works, Glasgow. Progress with "running-in" operations on this unit is stated to have been satisfactory, and full production is expected shortly.

Scottish Coal.—There was a steady increase in colliery outputs in the first three weeks of January, the figures being 185,300 tons, 466,400 tons, and 486,100 tons, respectively. Satisfaction regarding the improvement has been qualified, however, as the total for the two full weeks has already fallen 47,500 tons short of the target figure. Consumers generally are still comfortably placed for stocks, the position comparing very favourably with that of a year ago. Current deliveries have been steadily maintained, and only a major stoppage at the pits, or exceptionally heavy snowfalls are likely to cause fuel users any anxiety. During the recent cold weather, the peak demands for electricity have been just within the limits of generating capacity, but coal supplies have been ample for the power stations. Gasworks and steelworks are comfortably placed for supplies. The production of coking coals has ensured maximum operations at the ovens, but the output of metallurgical coke is still short of local needs. Domestic coal deliveries have been less than allocation in the past few weeks. Export inquiries are tending to increase, Norway being notably interested; substantial tonnages for Sweden have been stemmed up to the end of February. Periodic shipments have also gone to France and Portugal, but activity has been somewhat restricted in the Irish market.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Export trade has provided some encouraging features on the Welsh steam-coal market throughout the past week. A good inquiry was circulating, but the amount of new business that salesmen could entertain was strictly limited owing to the heavy calls made by home consumers. The most important development was the resumption of shipments to Italy. This trade had been in abeyance since Italy entered the war in 1940. A cargo of about 6,000 tons was arranged, and it was hoped that further business would follow. Before the suspension of shipments, Italy bought considerable quantities of Welsh coals, and in 1938, the last pre-war year for which figures are available, took about 1,130,000 tons from local shippers. The Rio Tinto Company have secured about 3,500 tons of Welsh coals. This will be the second shipment to Huelva since the resumption of deliveries, and it was understood that it had been arranged on a kind of barter plan under which a cargo of copper ore would be supplied in return. Further business was available from Lisbon, while an expansion of activities to include some of the South American countries was expected shortly. The demands of the high-priority and leading industrial consumers in the inland section provided a ready outlet for the bulk of current outputs, and there was no sign of a reduction in the demand from these sources. Cokes and patent fuel were well sold forward and supplies were not easy to secure for early delivery.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, the demand for tin-plates was steady and that a fair volume of business was taken by makers, who have good order books for the current quarter. The export market is displaying greater activity and an increased number of orders is being placed for delivery during the next three months or so. Steel sheets are unchanged; the demand is as strong as ever and much in excess of the make. Iron and steel scrap is in great demand as all the steelworks are in need of quick deliveries.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—High-grade steels are being produced on a larger scale at plants able to get sufficient raw materials. The highest outputs are from basic furnaces using fuel oil to the extent of 60 per cent. Many makers of steel products are unable to obtain delivery of all the high-carbon steels they require and, in consequence, are unable to operate their plants at full capacity. The labour supply is increasing gradually as foreign labour is absorbed into the iron and steel foundries, rolling mills and forges, but more skilled labour would be welcome. Special steps for the more rapid repair of wagons are having satisfactory results. Railway material is not quite so difficult to secure now that the scarcity of steel is not so acute as it was. Enough iron and steel scrap, however, is not forthcoming to satisfy the requirements of the steelworks. There is a steadier flow of pig-iron as a result of a slight improvement in the supply of hard coke. The prolonged delays in securing delivery of the machine tools required for carrying out schemes of extension and re-equipment have not been relieved to any extent, the difficulty being lack of sufficient labour.

South Yorkshire Coal Trade.—Better supplies of deep-mined coal and the satisfactory working of schemes to clear colliery and railway sidings of loaded wagons and return empties to the screens more expeditiously, have increased the available supplies to such an extent that even the larger consumption of locomotive and industrial steams is leaving satisfactory reserves. The position has been improved by satisfactory production at opencast sites under good weather conditions. More coking coal is reaching the coke-works which are producing more coke to relieve the scarcity. It is computed that by about May it will be possible to spare sufficient coal to restore a good part of the former overseas business.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The North-East Coast continues to turn out considerably more iron and steel than other home producing centres, but the supply still falls inconveniently short of the demand. The output of Cleveland ironstone remains below the current needs of users, necessitating the continued employment of costly foreign ore. The distribution of scrap is rather better than of late, but is still far from sufficient for the users' requirements, while pig iron supplies will have to be much increased to meet the demand. Steel manufacturers cannot cope with the intense pressure for larger supplies.

Foundry and Basic Iron.—Cleveland foundry pig iron is almost unobtainable and there seems little likelihood of an early resumption of the make. For some time North of England consumers have had to draw supplies from other producing centres. The substantial output of the basic blast-furnaces barely suffices for the essential requirements of the local steel furnaces.

Hematite, Low-Phosphorus and Refined Iron.—The output of Tees-side brands of hematite is sufficient for the urgent needs of regular users, but leaves no surplus for replenishing stocks. Low- and medium-phosphorus grades of iron are in steady request and refined-iron manufacturers can readily dispose of their products.

Manufactured Iron and Steel.—Producers of semi-finished and finished iron have a lot of work on hand and the commitments of the steel makers are still embarrassingly heavy. The demand for steel semies is still considerably greater than makers can meet and the imports of overseas products are below expectations. The heavy demand for billets and sheet bars continues. Sheets, railway material and colliery equipment are in great demand. The census of steel stocks at the end of 1947 and of consumption in the fourth quarter of last year is being taken, but some time must elapse before the information can be collated. In the meantime, the proposed new system of tonnage distribution is giving rise to considerable criticism.

RECTANGULAR-PIN FUSED PLUGS AND THE D.S. FUSED PLUG.—A broadsheet, issued by Messrs. Dorman and Smith, Limited, 32, Queen Victoria-street, London, E.C.4, in association with Messrs. D.S. Plugs, Limited, and Messrs. A. Reyrolle and Company, Limited, deals with certain points in the plug and socket controversy of which we gave an account on page 496 of our 164th volume. It is argued that it is safer and more convenient to incorporate the fuse in one of the pins, as is done in the D.S. plug, than to house it in the body of the plug, as recommended in B.S. No. 1363. Moreover, the latter design is said to be untried, while the former is being used by 300 British supply undertakings. New factories, one of which is nearing completion at Workington, Cumberland, are being built for the production of the D.S. Plug.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

SOCIETY OF ENGINEERS.—Monday, February 2, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. Presidential Address, by Mr. E. E. Turner.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, February 2, 6 p.m., James Watt Institute, Birmingham. "Standardisation of Switchgear," by Messrs. D. E. Lambert and J. Christie. Also at the *North-Western Centre:* Tuesday, February 3, 6 p.m., Engineers' Club, Manchester. *Mersey Centre:* Monday, February 2, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. Report on "Practical Training of Professional Electrical Engineers." Also at the *Southern Centre:* Wednesday, February 4, 6.30 p.m., Technical College, Brighton. *Radio Section:* Wednesday, February 4, 5.30 p.m., Victoria-embankment, W.C.2. "Frequency Modulation for V.H.F. Multi-Channel Radiotelephony," by Messrs. J. H. H. Merriman and R. W. White. *Institution:* Thursday, February 5, 5.30 p.m., Victoria-embankment, W.C.2. "A Survey of the Telephone Rating Problem," by Mr. L. C. Pocock.

INSTITUTE OF TRANSPORT.—*Metropolitan Section:* Monday, February 2, 6 p.m., Livingstone House, Broadway, S.W.1. "Cargo Problems of Carriage by Sea," by Mr. C. H. Minett. *Sheffield Centre:* Monday, February 2 7.30 p.m., Royal Victoria Hotel, Sheffield. "Control Methods of the L.M.S.," by Mr. E. A. Parnell. *Midland Section:* Tuesday, February 3, 6.30 p.m., Imperial Hotel, Birmingham. "Exports and Port of London Authority," by Mr. P. J. Fossey. *Southern Section:* Wednesday, February 4, 5 p.m., Harbour Board Offices, Southampton. "Education for Management in Transport."

INSTITUTION OF PRODUCTION ENGINEERS.—*Yorkshire Section:* Monday, February 2, 7 p.m., Technical College, Keighley. "Automatic Loom," by Mr. H. D. Gaudin.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 3, 5.30 p.m., Great George-street, S.W.1. Debate: "Are the Construction Methods of British Civil Engineering Contractors Sufficiently Progressive?" For: Mr. H. J. B. Harding. Against: Mr. G. K. Bell. *South Wales Association:* Tuesday, February 3, 6 p.m., Town Hall, Newport. "Organisation of Civil Engineering Works," by Mr. R. W. Horner. *North-Western Association:* Thursday, February 5, 6.30 p.m., Engineers' Club, Manchester. "Pre-Stressed and Post-Stressed Concrete," by Mr. W. E. I. Armstrong.

ROYAL SOCIETY OF ARTS.—Wednesday, February 4, 2.30 p.m., John Adam-street, W.C.2. "Education for Management," by Lieut.-Col. L. Urwick."

INSTITUTION OF MECHANICAL ENGINEERS.—*London Graduates' Section:* Wednesday, February 4, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Light Metals in the Automobile Industry," by Mr. O. S. Plail. *Scottish Branch:* Thursday, February 5, 7.30 p.m., Royal Technical College, Glasgow. Thomas Lowe Gray Lecture on "Gas Turbine and Marine Propulsion," by Mr. T. A. Crowe. Also Friday, February 6, 7.45 p.m., Robert Gordon's College, Aberdeen; and Saturday, February 7, 7.15 p.m., Technical College, Dundee. *Institution:* Friday, February 6, 5.30 p.m., Storey's-gate, S.W.1. "Mechanical Engineering Aspects of Naval Mining," by Dr. E. C. Wadlow. "Mechanical Features in Anti-Submarine Weapons," by Mr. J. M. Kirkby. *Automobile Division:* Tuesday, February 3, 6 p.m., Storey's-gate, S.W.1. "Petrol-Injection Equipment Development," by Messrs. K. Brook and W. E. W. Nicholls.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—*East Midlands Branch:* Wednesday, February 4, 6.30 p.m., Gas Showrooms, Parliament-street, Nottingham. "Electrical Energy for Heating and Ventilating," by Mr. P. A. Moore.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties' Branch:* Wednesday, February 4, 6.30 p.m., Neville Hall, Newcastle-upon-Tyne. "Modern Industrial Design," by Mr. C. A. Harding.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Wednesday, February 4, 6.30 p.m., 95, New-street, Birmingham, 2. "Experiments in the Chemical Industry," by Mr. K. Brownlee. Friday, February 6, 6 p.m., 2, Savoy-hill, W.C.2. "Quality Control in Europe," by Dr. Geiss.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, February 4, 7 p.m., James Watt Institute, Birmingham. "Power Plant Development in the U.S.A.," by Mr. L. F. Jeffrey. *Institution:* Friday, February 6, 6.30 p.m., 39, Victoria-street, S.W.1. "Power Transmission in Diesel-Electric Locomotives," by Mr. T. Schur.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, February 6, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Alternating Current for Ships' Auxiliaries," by Mr. A. N. Savage.

ROYAL ELECTRICAL AND MECHANICAL ENGINEERS IN THE FIELD.

(*For Description, see Page* 117.)

FIG. 1. SIX-WHEELED RECOVERY TRACTOR.

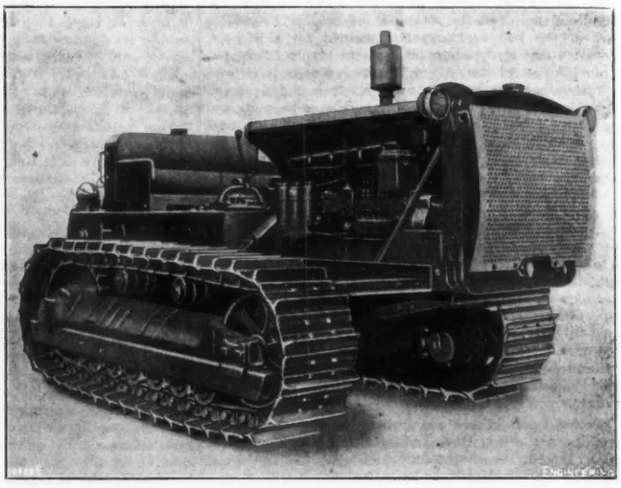


FIG. 2. "D8" TRACTOR FOR RECOVERING ARMOURED VEHICLES.

FIG. 3. SHERMAN ARMOURED RECOVERY VEHICLE, MK. II.

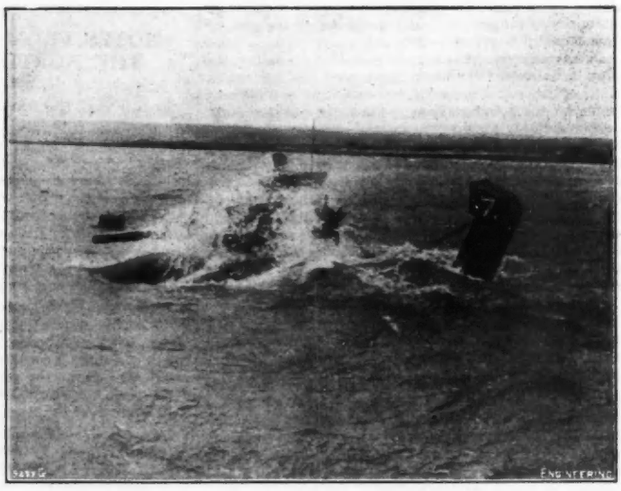


FIG. 4. WATERPROOFED TANK APPROACHING SHORE.

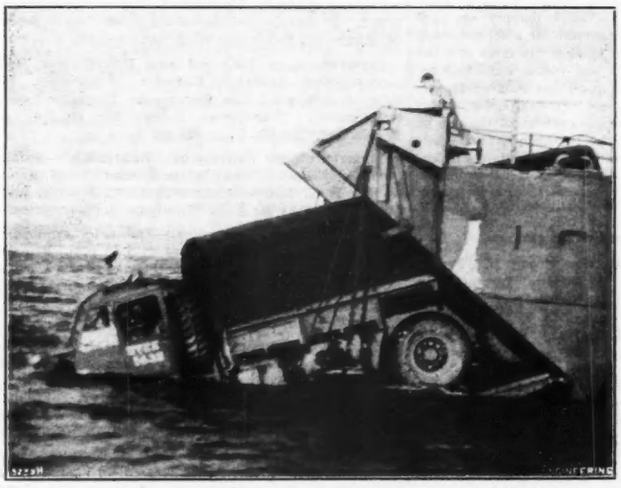


FIG. 5. 10-TON LORRY LEAVING RAMP.

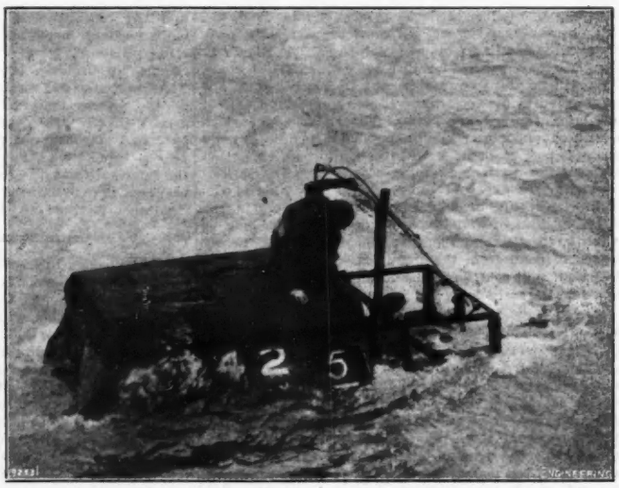


FIG. 6. LORRY "WADING."

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:

"ENGINEERING," LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

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Accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

SUBSCRIPTIONS.

"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance:—

For the United Kingdom and all places abroad, with the exception of Canada	£4 10 0
For Canada	£4 5 0

Subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, mentioning the agent's name and address.

ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

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THE NEED FOR INCENTIVES.

THE passion for planning, and especially for planning the activities of others, is no new weakness, nor was the advent of a Socialist Government needed to stimulate opposition to its growth. The war was still at its height when Lord Elton, in what connection we do not now recall, was moved to point out, as a powerful argument against this excessive desire to regulate, that nobody had planned the British Empire. It grew, he said, "because men and women went where adventure and opportunity beckoned, while Civil Servants wrung their hands in alarm or pasted their memoranda on the parish pump. All our great rivals were States which closely planned and controlled their imperial enterprises, and we outstripped them all. In our plans for the future," Lord Elton implored, "let us leave some room for merchants and for adventure." In short, it might be added, leave us at least a few completely uncontrolled incentives, to choose or to ignore as we may feel disposed; for the freedom to ignore what is to others an incentive to action is in itself often a beneficial stimulus to the mind. He was a wise man who had the courage and candour to declare that "time one enjoys wasting is not wasted time."

Within the past few years, millions have been deprived of the incentives that they and their fathers used to know and respond to, and have not yet had the time to accustom their minds to the loss and to frame the new incentives that they must have, whether they realise it or not, if they are to avoid mental stagnation. The process has been going on, indeed, for many more than just a few years; for example, it is exceptional now, after several generations of compulsory education, to find among ordinary people something of the burning urge for knowledge which marked the first half of the Nineteenth Century. Instead, as the pursuit of knowledge for its own sake was gradually superseded by the struggle to assimilate enough of the mass-produced knowledge to keep abreast of the crowd, there developed the incentive to apply the more freely distributed knowledge in novel and often profitable ways; sometimes merely to gain a financial advantage, but more often to achieve the distinction of doing and being something different from the general crowd, to excel in some direction that would produce a sense of satisfaction in itself apart from any benefit such as social or financial advancement, or an added feeling of economic security and independence. Now the wheel has taken another turn, and the security is to be assured to all, even though at the price of a sacrificed independence in many cases. Once again a partial vacuum has been created and something must be found wherewith to fill it.

The failure to recognise that fundamental need, or, at least, to give due weight to it as a guide to policy, is one of the most serious weaknesses of modern over-planned civilisation. Dean Inge, in one of his terse little essays, stated the position with uncompromising bluntness. "Nine people out of ten," he declared, "will only give their best work if they have something to gain or something to lose. Hope and fear always have been and always will be the main incentives . . . Without hope and fear, good work will not be done, and if it must be done, fear will have to be re-introduced in one form or another." If, he continued, fear is not introduced, then, as he quoted the Emperor Tiberius, "Industry will languish, idleness will be encouraged . . . everyone will indolently expect help from others, useless themselves and a burden to the government."

Before condemning those observations as sheer "reaction," it is worth while to consider just how much the working population of any industrial nation—not necessarily Britain—has lost in the way of incentives by the gradual disappearance of the manual craftsmanship that machines have so largely displaced. In modern manufacturing processes of the more highly mechanised types, the man has become merely incidental to the machine; fitting, for example, has practically vanished from the production schedules of many factories making engineering products, except for the work of a few plant engineers whose function it is to take the place of the old-time millwright. Even if the machine breaks down, in the modern factory the man who tends it has nothing to do with putting it right; he is shifted to another machine. From the production point of view, it is well that this should be so; indeed, it is essential. On no other basis could modern production be sustained; but it has resulted in an enormous increase in the number of employees whose chief creative satisfaction is not in what they do in their working hours, but in the occupations to which they escape from the factory. If they have not yet attuned their minds to find some other satisfaction in this way, a sense of unrest and frustration quickly grows upon them, which the artificial amusements of urban existence cannot always assuage.

In these circumstances, the people of Britain are undoubtedly better off than most, because in no country are there more outlets for unpaid activity or a larger proportion of the populace ready to take advantage of them. By contrast, the people of France, for instance, miss a great deal, and much of the unrest which has distinguished that great nation in recent years may be attributed to just this cause. Germany, at the present time, is in even worse case and is likely to remain so until some means can be found to fill the vacuum. To return nearer home, however, it would seem that there is still a great need, in most branches of industry, to combat the idea that, because machines do so much of the work which used to be done by hand, individuality is at a discount. To a certain extent, a collective pride can take the place of individual pride, and much is being done, in many works, to inculcate that very proper feeling. More might be done, however, to bring home the fact that there are still many directions in which craftsmanship is essential, though it may not be precisely the kind of craftsmanship that brought the satisfaction of achievement to earlier generations.

For that reason, we welcome particularly the emphasis laid upon this factor by Mr. Oliver Lyttelton, M.P., when he opened the Gauge and Tool Exhibition on January 26, at the Royal Horticultural Hall, London, where it continues until February 6. Mr. F. W. Halliwell, President of the Gauge and Toolmakers' Association, in introducing Mr. Lyttelton, had gone so far as to claim that the industry which it represents is "the

last stronghold of craftsmanship," a thesis which might be disputed, though there is certainly none which sets a higher standard; but Mr. Lyttelton, brought in also the stronger argument, as it appeared to us, of the vital part that is played by this industry in relation to other industries, and their dependence upon the maintenance of high standards among the makers of gauges and the small tools which are the concern of the Association's members. There, by implication, he touched upon one of the most potent of all incentives—the realisation that upon the quality of the individual toolmaker's work depends the quality of the work of countless others. The "fear" incentive on which Dean Inge placed such stress is not only—perhaps, not even mainly—the fear of reprisals; in many cases, it is the fear of failing to maintain the individual's own standard. When that self-imposed criterion has been reached and passed, the satisfaction is correspondingly great. The standards of craftsmanship of to-day may or may not compare with those of yesterday—that must be largely a matter of opinion; but we do believe that there is still a large proportion of the working population of this country who, while they would be annoyed, depressed or extremely angry at being dismissed for work that was deficient in quantity, would be much more deeply hurt if they were discharged because it was deficient in quality. That is an aspect to which trade unions might devote more attention than they do, for they would not lose by it in the long run.

To those who have the technical knowledge or the imagination to see beyond the mere surface finish—or to appreciate surface finish, in the modern technical sense of the term—there is no more interesting exhibition than that of the gauge and tool makers; but, inevitably perhaps, it is "caviare to the general," with little of the popular appeal which characterises, for example, the Engineering and Marine Exhibitions and the Radio Exhibitions, which are regular features of the London scene. It is an exhibition organised by specialists for specialists; and although, this year, the Gauge and Toolmakers' Association have joined forces with the National Federation of Engineers' Tool Manufacturers and so have somewhat widened the field, this characteristic is still predominant, and is likely to remain so. The suggestion might be worth considering, however, to extend its educational usefulness by following the example set by the Worshipful Company of Shipwrights, in the exhibition illustrating their highly specialised craft which was held in the same hall about a year ago.

One of the main purposes of that exhibition, as was clearly avowed by the Shipwrights' Company, was to interest and attract boys and youths, who might be led thereby to make shipbuilding their career. With that object, special arrangements were made to facilitate their attendance and to describe clearly to them how to enter the industry, how it functioned, what prospects it offered, and, especially, something of the various trades concerned in it and the subdivisions in which an entrant might seek for opportunities to specialise. The potential financial returns were not ignored, but the main emphasis was upon the fundamentally interesting nature of most of the work associated with the designing, building and operation of ships. Essentially, the policy was a long-term one, and probably no detectable results are yet to be recorded; but psychologically the approach was sound—much more so, in our opinion, than the rather depressing disquisition upon social security which Mr. James Griffiths, M.P., the Minister of National Insurance, contributed to the Oxford Management Conference on "Incentive" in September last. To most exhibition-stand attendants, an incursion of boys and youths is something of a nightmare, but it might be well worth while, nevertheless, to make some special provision in future Gauge and Tool Exhibitions for demonstrations, primarily designed for such audiences, of the actual processes of gauge and tool making, with simple expositions of the uses of the products and of the attractions of a craft which, properly learned, gives to a man a skill which is marketable almost anywhere in the industrial world, a considerable degree of economic security, and the deep-rooted satisfaction which is one of the most valuable of incentives.

PROFESSIONAL SALARIES.

THERE has been considerable discussion in recent months about the salaries paid to teachers of scientific subjects in schools, it being contended that these are too low to attract the more able men, many of whom tend nowadays to seek industrial employment. This matter is not of direct interest to engineers, who hardly figure among the ranks of schoolmasters, but definitely concerns physicists and chemists; and in some sections of electrical engineering it may be difficult to distinguish between a physicist and an engineer. If teaching appointments in technical colleges are brought into the discussion, practically every branch of engineering is involved and it may be argued, quite reasonably, that the salaries offered for these posts are not high enough to attract the best type of man unless he is influenced by causes not directly related to money payments, such as a natural interest in teaching, or the prospect of longer annual holidays than he is likely to get in an industrial firm.

Teachers' salaries, both in schools and technical colleges, are regulated by the Burnham Scale. This has the advantage that individual authorities, some of whom have parsimonious ideas, are forced to conform to a reasonable standard, but it has the disadvantage that its rigidity make no provision for the unusually brilliant man, who is perforce ranked with the mediocre. This procedure is in line with the whole trend of present-day administrative opinion, which is inclined to apply Burns' phrase, "A man's a man for a' that," with undesirable rigidity. In practice, "one man is as good as another"; extreme Left-Wing opinion might say, "he is better," but, in this country at least, matters have not progressed to the stage at which technical competence is measured in terms of political opinion. As a matter of practical procedure, it is necessary that standards of remuneration should be laid down to cover a widespread sphere of employment administered by public authorities, but that is no reason why their inherent disadvantages should be ignored, and it is of national interest to inquire whether, under the present system, State or local-council controlled educational institutions recruit such able teachers as public schools or the more independent universities.

In industrial life, the wages of workpeople are as rigidly controlled by outside authority as are the salaries of teachers in State-aided schools, and from the point of view of the authority concerned in any particular case, one man is certainly as good as another. More than once, suggestions have been made that professional engineers should organise themselves so that they will be in a position to dictate a scale of salaries for the various grades. Although it has been pointed out that the medical and legal professions have formed bodies which, in effect, are trade unions, the leading engineering institutions have always refused to have anything to do with such activities. Their authority in the scientific and technical spheres could only be weakened by undertaking semi-political activities. If professional engineers, as a body, are ever to be in a position to dictate salary rates, the necessary steps will have to be taken by some organisation other than the engineering institutions, and it does not appear that any such organisation is yet in existence.

The latest body to interest itself in this matter is the Association of Scientific Workers, which has issued a "Charter for Technical Staff in the Engineering and Metallurgical Industries." The weight to be given to this document must naturally be influenced by the percentage of the membership of the Association which is represented in these two spheres of activity, and the aggregate number of engineers and metallurgists which that percentage represents; no information is given on these subjects. It is stated that the salary rates proposed have been "correlated with the Civil Service grades" and that "workers resident in the London Area should receive a special cost-of-living bonus of the order of that received by professional Civil Servants," but this is hardly a correct statement of present practice. Consolidated salaries have now been introduced, the basic rate for a job being the London rate and a deduction being made for provincial appointments, the rate for large provincial towns lying intermediately between those of London and the country areas.

The salary arrangement in operation for professional civil servants certainly forms a working example of the type which the Association desires to introduce for engineers and metallurgists in general, but the mere fact that some procedure is in operation in a particular sphere is not in itself a proof that it is suitable for other and wider application. As in the case of schoolmasters, it is probably an administrative necessity that standard rates should operate in the Civil Service and, apart from the fact that public money is concerned, it would hardly be allowable for one section of a single organisation to compete against another section for the service of able staff. That, however, is not the only disadvantage that the system may have; one of its unquestionable results is that some of the most brilliant and original men pass out of State service because the rigidity of the salary system prevents adequate financial recognition of their merits.

Although the term "professional civil servants" covers a wide range of activity, it does not embrace a tithe of the multifarious duties carried out by engineers and metallurgists in industrial practice, where a formula which would be fair to every type of employee would be very difficult to devise. The Association proposes Senior Engineers or Metallurgists and two lower grades. This may be compared with the Civil-Service system which has been introduced in which civil servants of the type concerned are divided into Scientific Officers and Experimental Officers, there being three grades in each class. The former are the senior, and the head appointment is Principal Scientific Officer. This system is new and has hardly settled down to steady operation. Many present employees are not clear about the relation of the two main classes, although it has been suggested, probably by an Experimental Officer, that the business of Experimental Officers is to do the work and the business of Scientific Officers is to tell them to get on with it. The salary of a Senior Experimental Officer is higher than that of a Scientific Officer, so that it would appear that, if a man is transferred from the lower to the higher grade, he would actually qualify for a low salary unless he were placed in a senior position on the higher grade. The whole system is of recent introduction and possibly no transferences have yet been made, but there is some speculation among the ranks of the "goats," represented by the Experimental Officers, about the conditions under which they may be transformed to "sheep."

Probably the nearest parallel between the work of engineers and metallurgists in the Civil Service and those employed in industry is furnished by the large number of research establishments which are now sponsored by the State. It may be that the somewhat artificial division between science and experiment which has been introduced may suit the activities of these organisations, but it is doubtful if it could be employed in industry generally with either convenience or fairness. In their Charter, the Association of Scientific Workers have not attempted to devise a procedure based on this model; their classification is less definite, but, for that reason, would be more difficult of application. With a rigid division between Experimental and Scientific Officers, an employee will know exactly where he stands from the salary point of view and also that his ambition will probably have to be limited to the possibility of becoming a Senior Scientific Officer, the only higher post, of which there are but few, being Principal Scientific Officer. The Charter lists two grades of juniors, and Senior Engineers paid according to two scales. These Senior Engineers are defined as men in charge of groups of juniors or "persons with special experience engaged in work calling for a high degree of initiative and originality." The fact that no information is given about who is to define what work comes within this class illustrates the difficulty of the task which the Association has undertaken. In practice, the only person who can determine this matter is the employer. This is the present practice and he pays an adequate salary if he wants the work carried out properly, because he has to.

NOTES.

NATIONALISATION OF THE GAS INDUSTRY.

A BILL providing for the transfer of the whole of the British gas industry to public ownership, and for the establishment of 12 Area Gas Boards and a central Gas Council, was issued at the end of last week. Although similar in form to that laid down for the electricity supply industry, the new organisation shows some important practical differences. The Area Boards are given the duty of developing and maintaining "an efficient co-ordinated and economical system of gas supply for their area" and an "efficient and economical production of coke." They will also have power to manufacture and sell products derived from carbonisation, so that there will be a considerable measure of decentralisation. The central authority, instead of being concerned with generation, as in the case of electricity, will be, in fact, largely advisory; it will consist of an independent chairman, deputy chairman, and all the chairmen of the Area Boards. The Boards themselves will consist of from seven to nine members, all the appointments being in the hands of the Minister of Fuel and Power. In addition, there is to be a Consultative Council in each area, which will consist of between 20 and 30 members. Half of these members will be appointed from local authorities in the area, while the remainder will be representative of consumers and other persons or organisations interested in the development of gas. Charges, tariffs and the provision of new and improved services will also come under their scrutiny. They may make representations direct to the Minister, who may in turn refer matters to them for inquiry and report. The boundaries of the Areas also differ from those laid down in the Electricity Act. Wales and Scotland each form one area. On the other hand, London is divided by the Thames. The river will, in fact, form the boundary between the South-Eastern Area, which extends from South London to the coast, and the North Thames area, which corresponds roughly to the area at present supplied by the Gas Light and Coke Company. The outer portions of north and west London will form part of the Eastern and South Midlands Areas, respectively. Compensation will be paid to holders of securities in gas companies in the form of stock issued by the Gas Council and guaranteed by the Treasury. Local authorities will be compensated for their gas undertakings on the basis of the outstanding net debt, the lines followed being generally the same as those laid down in the Electricity Act, 1947. Provision is made, however, for settling the value of unquoted stock and for an addition to Stock Exchange values where these can be shown to have been substantially depressed by war damage or evacuation. An aggregate sum of 2,000,000*l.* will be made available to local authorities to compensate for "severance." In addition to the compensation stock, the Gas Council will be authorised to raise a further 250,000,000*l.* for future development.

THE THOMAS LOWE GRAY LECTURE.

The 20th Thomas Lowe Gray Lecture, entitled "The Gas Turbine as Applied to Marine Propulsion," was delivered before the Institution of Mechanical Engineers by Mr. T. A. Crowe, M.Sc., member of Council, on Friday, January 23, 1948, with the President, Lord Dudley Gordon, D.S.O., in the chair. The author commenced with a review of the development of the gas turbine since John Barber's patent in 1791, and noted that, although it was only eight years since Professor A. L. Mellanby delivered the 12th Lecture—on "Fifty Years of Marine Engineering"—a new prime mover for ships had appeared since then. Stirling had patented an engine in 1827 which was the first to incorporate a regenerator. The drawings of Mennon's patent (1861) and Charles G. Curtis's patent (1895) bore a striking resemblance to present-day designs, but they failed in practice owing to lack of materials to withstand the high temperatures, and to the low efficiencies of the compressors and turbines. The compressors absorbed more power than the turbines, and it was impossible, therefore, to run the plant without supplying power to it. Mr. Crowe showed some interesting graphs of possible efficiencies (turbine, compressor, and overall thermal), plotted on a time basis from 1900 to the present day, but he pointed out that they did not represent the history of the gas turbine. He then described the several gas-turbine systems, and referred briefly to air heaters, heat exchangers, materials, and systems of control. For marine purposes, a life of 100,000 hours at full load and temperature was required, but at present they had little data for such a design. He thought that gas turbines, because of their small number of working parts, would eventually be as reliable and as low in upkeep costs as existing forms of motive power. A gas turbine of 5,000 to 10,000 shaft horse-power could be constructed to give a fuel consumption of 0·44 lb. to 0·46 lb. per shaft horse-power-hour, and this figure would be improved to compare favourably with that for a Diesel engine when metallurgical developments allowed the initial air temperature to be raised by 150 deg. F. The gas turbine was lighter in weight and occupied less space than an equivalent steam-turbine or Diesel plant. Mr. Crowe described some existing marine gas turbines, in particular the Metropolitan-Vickers plant which was installed in a naval gunboat in 1947, the Elliot-Lysholm marine gas turbine, sponsored by the United States Navy, a proposed Brown Boveri open-cycle marine plant, with two 7,000-shaft horse-power units, and a Sulzer semi-closed cycle gas turbine of 7,500 shaft horse-power, which is under construction.

REVISED STEEL ALLOCATION SCHEME.

An alteration in the present method of allocating steel to industry was explained by Mr. Douglas Jay, M.P., Economic Secretary to the Treasury, at a Press Conference on Tuesday, January 27. He recalled that, last winter, the system of allocation, which had been in use during the war, had been reinforced by the granting of special priority in certain cases. This special priority, which was commonly known as P.M.L. (Prime Minister's List), had been particularly designed to aid the supply and distribution of fuel and power. Although it was still necessary to expand fuel and power resources, and to improve transport, it was equally essential to increase the nation's exports and to reduce imports. In future, therefore, priority would only be granted in individual cases and to selected items where departments were satisfied that its application to an order for steel of a stated type would prevent a hold-up in essential production. Mr. Jay laid emphasis on the point that all priority authorisations would rank equally and "would be given against the background of the principal current needs." These needs were to expand production for export, to ensure that exporting firms were supplied with components, and to enable basic industries, such as coal, steel, electric power, transport and agriculture to achieve their targets. The revision would also enable the large arrears of orders to be eliminated and deliveries to be matched with authorisations. The allocation and distribution of iron castings would be operated in the same way, and a similar limited-priority procedure would apply. As little difficulty had been experienced in ensuring that deliveries of materials other than iron and steel matched allocations, the P.M.L. symbol would be no longer used in such cases; also there would be no system of allocation or priority for manufactured components, such as ball bearings and electrical equipment, owing to the complications involved. Where, however, difficulties arose in the delivery of these components, manufacturers could seek assistance from the Regional Officer of the Department concerned. The decision as to whether an industry should have a priority supply would lie, in the first instance, with the appropriate production department, the Chancellor of the Exchequer being the final court of appeal.

GIFT FROM AUSTRALIA TO THE ROYAL OBSERVATORY.

The observatory at Melbourne has been closed recently, and much of its work has been taken over by the Commonwealth Observatory at Mount Stromlo, near Canberra. The transit circle at Melbourne, made by Troughton and Simms, and set up there in 1884, was not needed at Mount Stromlo, so that, when Sir Harold Spencer Jones, the Astronomer Royal, during a visit to Australia last year, saw the instrument and intimated that it could be usefully employed in the new Royal Observatory at Herstmonceux, the Government of Victoria, with characteristic generosity, presented it to the British Government for that purpose. The instrument, which has now arrived in this country, has an 8-in. object glass with a focal length of 12 ft., and is provided with two graduated circles 3 ft. in diameter; several improvements were made to it while in service at Melbourne. At the Royal Observatory it will supersede the historic Airy transit circle, which has now become obsolete but has served to define the position of the Greenwich meridian since it was installed in 1851. This instrument is to be left at Greenwich, with a collection of more ancient astronomical instruments, to form an historical exhibit for the benefit of visitors. It may be noted that the Royal Observatory also possesses a more modern transit circle, made by Cooke, Troughton and Simms and installed at Greenwich in 1936. The two transit circles will be used at Herstmonceux for the numerous meridian observations to be undertaken there.

SHORTAGE OF ELECTRICAL GENERATING PLANT.

A brief, but informative, debate on the Government's proposal to decelerate the provision of electrical generating plant was opened by Mr. W. C. Palmer in the House of Commons on Friday, January 23. The position, he said, was that although between 1939 and 1946 the increase in the demand for electricity had been rather less than would have been expected under normal pre-war conditions, there was a gap of about 2,000 MW between that demand and the plant capacity available to meet it. Moreover, it was estimated that, by the winter of 1951-52, the total demand would be about 14,500 MW, or 4,000 MW more than at the present time. About 6,000 MW of plant would be required, therefore, to make up the deficiency during the next four years; and it seemed to be taken for granted that four years from now some 1,000 MW of capacity would still be lacking. The seriousness of the position was further indicated by the fact that only 790 MW of new plant had been brought into service during the past two years, and he asked, therefore, whether the expected extra 1,600 MW would really be available in 1949. In reply, the Parliamentary Secretary to the Ministry of Fuel and Power (Mr. A. Robens) said that, at the end of January, 1947, there was a gap of 2,000 MW between the available generating plant and the potential demand. "Staggering" had been introduced to bridge this gap; and it was estimated that, as a result, between 750 MW and 1,000 MW of load had been transferred from the peak. With regard to the future, 1,150 MW and 1,600 MW were scheduled for installation during 1948 and 1949, respectively, and these figures would not be affected by the cut in the investment programme. This cut would, however, become effective in 1950 and 1951, with the result that the 2,000 MW of plant which it had originally been intended to instal in both those years would be reduced to 1,500 MW. On the basis of these estimates, which must obviously be subject to review, there would be a margin of 500 MW in 1951-52, and this should have increased to 890 MW in 1952-53. At present, extensions amounting to 1,635 MW were actually in hand at 31 stations. In addition, 21 new stations, representing a further 2,642 MW, were under construction.

POWER FROM THE WIND.

Investigations directed towards the utilisation of wind power on a large scale are to be undertaken by the British Electrical and Allied Industries Research Association and a new Section on Power Generation has been set up. Interest in the economic possibilities of such developments have been raised by the successful operation of the 1,000-kW plant, situated on the 2,000-ft. mountain known as Grandpa's Knob in the State of Vermont, in the United States, a description of which appeared on page 81 of our 154th volume (1942). As recorded in our issue of August 29, 1947, the matter has been followed up in that country by the Federal Power Commission, who have made extensive

studies and prepared detail designs for 7,500-kW and 6,500-kW wind-power electric generating plants. The terms of reference of the new section of the Electrical Research Association are "to study the technical and economic problem of large-scale aerodynamic generation. In Great Britain; including the collection of all available information and evidence, the principles of the selection of sites and the wind energy derivable therefrom, the co-ordination of wind-driven generators with supply systems, the essential design features of wind-driven generators and the design problems which remain to be solved." The chairman of the sectional committee is Mr. T. G. N. Haldane, and the members will include representatives from the electricity supply and electric manufacturing industries, consulting engineers, the Department of Scientific and Industrial Research, the Lord President's office, the Meteorological Office, the Ministry of Fuel and Power and the Ministry of Supply. Representatives of the aircraft industry will be invited as may seem desirable. Some work on small-scale wind-power generation has been done by the Section on Rural Electrification, from the point of view of electricity supply to small isolated communities in remote districts. The recent shortages of fuel and power, however, roused interest in the possibilities of wind-power generation on a substantial scale and, in December last, the Electrical Research Association convened a conference of Ministries and other bodies likely to be interested in the matter. The members of the conference were unanimously in favour of researches being undertaken and, as a result, the new Section has been set up.

LETTERS TO THE EDITOR.

ENGINEERING UNITS OF FORCE.

TO THE EDITOR OF ENGINEERING.

SIR,—There appears to be little doubt that, if the one pound mass be accepted as a fundamental unit, together with the foot, and the second as unit of time, then the poundal is the logical unit of force. However, engineers have come, through long usage, to accept the gravitational pull on one pound mass as the unit of force in all statistical problems, without any precise definition of the strength of the local gravitational field in which it should be measured. Because of the slow variation of the gravitational field this causes little inconvenience until dynamical problems are encountered, and then it is found that the standard gravitational acceleration at which the pound force is defined is required. Continued usage makes this quantity 32·2 ft. per second per second.

Having to accept the traditional system, it is left to the teacher to teach it. However strongly he feels about the illogicality of the present system, the teacher knows that the text-books, technical literature, examiners, and the bulk of other teachers are using it, and so he cannot afford to ignore it.

Mr. Lennie has correctly given the possibilities open to the teacher. The first choice is to use $F = K M a$, where force and mass are in pounds, and K is a non-dimensional constant, numerically 32·2. This has not been adopted to the writer's knowledge. Equations are invariably given as $F = M a$, $T = I \alpha$, K.E. $= \frac{1}{2} M v^2$, etc. The second is to write $\frac{W}{g}$ in place of M, W being the gravitational force on the body, in the same units as F. Dimensional considerations are satisfied by this equation, and it appears to be extensively used. Mass does not enter into the equations $F = \frac{W}{g} a$, $T = \frac{W}{g} K^2 \alpha$, etc., the unit of force varying from point to point since it is compared with the local value of W. All problems can be solved satisfactorily in this way, but the method is open to criticism from a teaching point of view. Not to use the term mass would be a bad policy, since it is freely used by scientists, and is taken to represent an intrinsic property of the body (which gravitational force is not). We are therefore unable to use the "poundal" system, and we must use the concept of mass; thus we are driven to use the third possibility, namely, to use the dynamical equations, with one pound as the unit of force, tacitly defined as the gravitational force on one pound mass at a point where the gravitational acceleration is 32·2 ft. per second per second. The unit of mass to be used must therefore be 32·2 times the standard pound kept in London.

The Americans who wrote to Mr. Lennie may have been correct when they said that they have no use for the last system and preferred the second, but they were not teachers faced with the above difficulties. Professor Perry was wise and a good teacher, and having to talk about these units of mass he invented the term "slug." Any teacher can appreciate the difficulty of talking about anything which has no distinctive name. It was suggested that the unit of moment of inertia does not have a name, but surely if we use the term "slug" for mass, moment of inertia will be slug-ft.²

Summarising, the present writer's opinion is that, since nothing short of legal enactments could make the "poundal" system universally used, it is best to define the unit of mass rigidly in relation to the standard pound, and call it the "slug."

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January 21, 1948.

AGE AND THE ENGINEER.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter from "Reservist," on page 63, *ante*, is particularly timely and touches a subject not only entailing hardship to the individual, but loss to national production.

Certain Government departments, I understand, are making, or are about to make, "temporary technical assistants" redundant in considerable numbers, and there is no balancing machinery to absorb them into industry. The 30 to 40 age-groups should have no difficulty in finding industrial appointments, but this is by no means the case with the 50 to 60 groups, as reference to your "Situations Vacant" columns will show. The newly constituted Engineers' Pool was a helpful move, but the selection board are not very much interested in "temporaries" of the older age groups. The Central (Scientific and Technical) Register is helpful also, but cannot in itself create a demand.

In addition to research, suggested by "Reservist" as a field for the older men, there is a variety of vocations where the experience, outlook, and judgment of men just past middle age would be beneficial rather than detrimental. They pulled their weight during the war: they should be allowed to do the same to-day. The Government, having largely accepted responsibility for employment, should not lose a moment in finding a solution to this serious problem.

Yours faithfully,
A.M.I.Mech.E.
London,
January 20, 1948.

CONFERENCE ON LARGE ELECTRIC SYSTEMS.—The International Conference on Large Electric Systems (Conference Internationale des Grands Réseaux Electriques) will be held in Paris from Thursday, June 24, to Saturday, July 3. The chairman of the British National Committee, for which the British Electrical Research Association acts as secretariat, is Mr. P. V. Hunter. Owing to difficulties of accommodation, intending delegates are requested to communicate with Mr. R. A. McMahon, secretary, British National Committee, C.I.G.R.E., Thorncroft Manor, Dorking-road, Leatherhead, as soon as possible. A provisional list of the papers to be submitted to the Conference will be given in Bulletin No. 1, which will be issued shortly.

MOBILE GAMMA-RAY SERVICE.—Commercial X-Rays, Limited, of Foundry-lane, Smethwick, Staffordshire, have recently extended their non-destructive testing services by the formation of a subsidiary company, Gamma Rays, Limited, of the same address. The depth of penetration obtained with present mobile X-ray equipment is rather limited, and assembly is difficult in confined spaces. These drawbacks are partly overcome by the use of gamma-ray equipment. The new company has been founded, therefore, to offer manufacturers the services of self-contained mobile units for the examination of metal sections by means of gamma-ray radiation. The cost of this technique is said to compare favourably with the charges for X-ray work of a similar nature.

PYTHAGOREAN NUMBERS.

By O. LICHTWITZ, M.I.Mech.E.

IT is well known that right-angled triangles exist, the sides of which are whole-number multiples of the unit of length. These ratios can be applied practically in staking out a right angle without the use of a T-square; for that purpose, however, the knowledge of one suitable triangle is sufficient. A wider knowledge is useful in designing spur gears, connecting shafts at different levels of a machine. In the case of the scheme below, it is desirable that the dimensions a and b should be round figures, and it is most convenient if the dimension c is a round figure, too.

The best known case is a triangle with the ratio of the sides 3 : 4 : 5, but there is an unlimited number of other triangles of that type. A triangle with the sides 6, 8 and 10 is obviously covered by the ratio above, and only groups of whole numbers will be considered which have no common factor. "Numbers" are here to be understood as positive whole numbers, and the term "triangle" will be used for right-angled triangles of the features set out above.

The general scheme for Pythagorean numbers is $a = 2pq$, $b = p^2 - q^2$, $c = p^2 + q^2$. Any whole numbers substituted for p and q make the three numbers integers which obviously comply with the condition $(2pq)^2 + (p^2 - q^2)^2 = (p^2 + q^2)^2$. The side $(2pq)$ must be an even number, and b and c must be either both even or both odd; but, as even values of b and c have a common factor with a, only odd numbers b and c need be considered. It follows from $b = p^2 - q^2$, that of p and q one must be even and one odd, and that $p > q$.

The values $p = 7$, and $q = 2$, for instance, lead to $a = 2 \times 7 \times 2 = 28$; $b = 7^2 - 2^2 = 45$; and $c = 7^2 + 2^2 = 53$.

The table on page 113, contains groups of numbers not exceeding 200, and also shows the angle α for each group.

It may be assumed that the angle α, in the diagram on page 113, is predetermined, with a small tolerance; the latter concession is necessary, as only odd and unlikely angles lead to suitable triangles. With the notation of the illustration,

$$\sin \alpha = \frac{a}{c} = \frac{2pq}{p^2 + q^2} = \frac{2\frac{q}{p}}{1 + \left(\frac{q}{p}\right)^2}.$$

As

$$\sin \alpha = \frac{2 \tan \frac{\alpha}{2}}{1 + \tan^2 \frac{\alpha}{2}},$$

it follows that

$$\frac{q}{p} = \tan \frac{\alpha}{2}.$$

The angle α may, for instance, be required in the neighbourhood of 60 deg., so that $\frac{q}{p} = \tan 30 \text{ deg.} = 0{\cdot}57735$. The rather coarse approximation $\frac{q}{p} = \frac{4}{7} = 0{\cdot}57143$ leads to the triangle (56, 33, 65) in the table, and the approximation $\frac{7}{12} = 0{\cdot}58333$ to the triangle (168, 95, 193); the error involved is, in both cases, about $\frac{1}{2}$ a degree. To obtain a better result, at the expense of high numbers, a closer approximation must be used. A trial by means of the slide rule, or a table of decimal equivalents of fractions, reveals the fraction $\frac{56}{97} = 0{\cdot}57732$; the values $p = 97$ and $q = 56$ pertain to the triangle (10864, 6273, 12545), and the angle α differs from 60 deg. by a few seconds only.

It is possible to find, for any given number for one side of a triangle, numbers for the other side and for the hypotenuse. The odd number 21 may serve as example.

$$b = p^2 - q^2 = 21,$$

or

$$(p + q)(p - q) = 7 \times 3, \text{ or } 21 \times 1.$$

The simultaneous equations $p + q = 7$, and $p - q = 3$, with the solution $p = 5$ and $q = 2$,

lead to the triangle (20, 21, 29). The simultaneous equations $p + q = 21$ and $p - q = 1$, with the solution $p = 11$ and $q = 10$, lead to the triangle (220, 21, 221). A solution thus exists for any number b, and several solutions if that number is not prime or the square of a prime number.

The even number 42 may be chosen for another example. One possibility of finding the two other numbers is to treat half of it (21) as demonstrated above, and to double the resulting numbers, thus leading to the triangles (40, 42, 58) and (440, 42, 442). A quicker way is to regard 42 as $a = 2p\,q$, or to assume $p\,q = 21$. The division into $p = 7$ and $q = 3$ leads to (40, 42, 58), and the division into $p = 21$ and $q = 1$ to (440, 42, 442).

While there is at least one triangle which contains a given side, the existence of a triangle with a given hypotenuse c is bound to the condition that $c = (p^2 + q^2)$ is the sum of two squares. It will be noted that most of the numbers c in the table are prime. There are, however, some composite numbers, such as 65, 85, 145 and 185, which are conspicuous by ranging twice in the table. The table contains, further, the numbers 25, 125 and 169, which, although composite, pertain to one set of numbers only. A more thorough scrutiny reveals that all these numbers are composed of prime numbers in the table; for instance, $85 = 5 \times 17$, or $125 = 5 \times 5 \times 5$, etc.

To ascertain whether a number can be split into the sum of two squares, it is advisable to factorise it. The number $322 = 2 \times 7 \times 23$, for instance, proves to be unsuitable because none of its factors is the sum of two squares. The number $323 = 17 \times 19$ has the suitable factor 17; the third group in the table, multiplied by 19, leads to the triangle (152, 285, 323). The number 325 is suitable, as all factors of $325 = 5 \times 5 \times 13$ are contained in the column c of the table; such cases are dealt with below.

If the intended hypotenuse c is a prime number, it must be found by trial whether it can be split into the sum of two squares. Because of $p^2 + q^2 = c$, and $p > q$, $p^2 < c$, and $p^2 > \frac{c}{2}$, so that

$$\sqrt{\frac{c}{2}} < p < c.$$

If c is, for instance, 317,

$$\sqrt{\frac{317}{2}} = 12{\cdot}6 < p < \sqrt{317} = 17{\cdot}8,$$

so that only the numbers 13 to 17 need to be tried; among them, 14 will be found suitable, as $317 - 14^2 = 317 - 196 = 121 = 11^2$. With $p = 14$ and $q = 11$, the triangle (308, 75, 317) is obtained.

Similarly, as $85 = 5 \times 17$ is the hypotenuse of two different triangles, any product of two prime numbers in the table can be split in two different ways into the sum of two squares. In this case,

$$c = c_1\,c_2 = (p_1^2 + q_1^2)\,(p_2^2 + q_2^2),$$

and it can easily be proved that

$$(p_1^2 + q_1^2)\,(p_2^2 + q_2^2) = (p_1\,p_2 - q_1\,q_2)^2 + (p_2\,q_1 + p_1 q_2)^2,$$

or

$$(p_1\,p_2 + q_1\,q_2)^2 + (p_2\,q_1 - p_1\,q_2)^2$$

The right-hand sides of both equations are the sums of two squares. If it is assumed that $(p_2\,q_1 + p_1\,q_2) < (p_1\,p_2 - q_1\,q_2)$, the former value is to be considered as the new q and the latter as p, so that

$$\tan\frac{\alpha}{2} = \frac{p_2\,q_1 + p_1\,q_2}{p_1\,p_2 - q_1\,q_2} = \frac{\frac{q_1}{p_1} + \frac{q_2}{p_2}}{1 - \frac{q_1}{p_1}\frac{q_2}{p_2}},$$

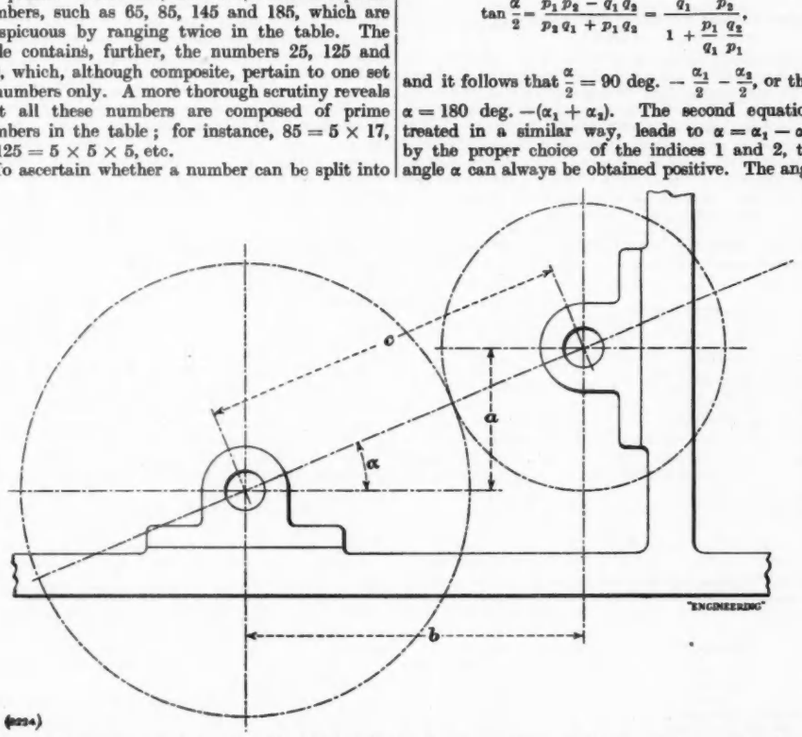
and it follows that

$$\frac{\alpha}{2} = \frac{\alpha_1}{2} + \frac{\alpha_2}{2},$$

or that $\alpha = \alpha_1 + \alpha_2$. In the case of $(p_2\,q_1 + p_1\,q_2) > (p_1\,p_2 - q_1\,q_2)$,

$$\tan\frac{\alpha}{2} = \frac{p_1\,p_2 - q_1\,q_2}{p_2\,q_1 + p_1\,q_2} = \frac{\frac{p_1}{q_1} - \frac{q_2}{p_2}}{1 + \frac{p_1}{q_1}\frac{q_2}{p_1}},$$

and it follows that $\frac{\alpha}{2} = 90$ deg. $- \frac{\alpha_1}{2} - \frac{\alpha_2}{2}$, or that $\alpha = 180$ deg. $-(\alpha_1 + \alpha_2)$. The second equation, treated in a similar way, leads to $\alpha = \alpha_1 - \alpha_2$; by the proper choice of the indices 1 and 2, the angle α can always be obtained positive. The angle α thus complies with the condition $\alpha = \alpha_1 \pm \alpha_2$; if $(\alpha_1 + \alpha_2)$ exceeds 90 deg., it is to be replaced by the supplementary angle (the angle by which it differs from 180 deg.).



(8224)

If $c_2 = c_1$, only one division of $(p_1^2 + q_1^2)^2$ into the sum of two relatively prime squares is possible, namely, $(p_1^2 + q_1^2)^2 = (p_1^2 - q^2)^2 + (2pq)^2$. That explains why, for $c = 25$ or 169, there is only one triangle in the table; in such cases, the angle $\alpha = 2\alpha_1$.

If c is the product of three prime numbers in the table, it will be found that c can be split into the sum of two squares in the following four ways:

$$(p_1^2 + q_1^2)\,(p_2^2 + q_2^2)\,(p_3^2 + q_3^2) = 1$$
$$= [(p_1\,p_2 - q_1\,q_2)\,p_3 - (p_2\,q_1 + p_1\,q_2)\,q_3]^2 + [(p_2\,q_1 + p_1\,q_2)\,p_3 + (p_1\,p_2 - q_1\,q_2)\,q_3]^2$$
$$= [(p_1\,p_2 - q_1\,q_2)\,p_3 + (p_2\,q_1 + p_1\,q_2)\,q_3]^2 + [(p_2\,q_1 + p_1\,q_2)\,p_3 - (p_1\,p_2 - q_1\,q_2)\,q_3]^2$$
$$= [(p_1\,p_2 + q_1\,q_2)\,p_3 - (p_2\,q_1 - p_1\,q_2)\,q_3]^2 + [(p_2\,q_1 - p_1\,q_2)\,p_3 + (p_1\,p_2 + q_1\,q_2)\,q_3]^2$$
$$= [(p_1\,p_2 + q_1\,q_2)\,p_3 + (p_2\,q_1 - p_1\,q_2)\,q_3]^2 + [(p_2\,q_1 - p_1\,q_2)\,p_3 - (p_1\,p_2 + q_1\,q_2)\,p_3]^2$$

It can be proved by considerations similar to the above that the angles in the four triangles are

$$\alpha_1 + \alpha_2 + \alpha_3$$
$$\alpha_1 + \alpha_2 - \alpha_3$$
$$\alpha_1 - \alpha_2 + \alpha_3$$
$$-\alpha_1 + \alpha_2 + \alpha_3.$$

If any of these angles exceeds 90 deg., it must be replaced by its supplementary angle; if any result is negative, the minus sign is to be disregarded. The number $c = 1{,}105 = 5 \times 13 \times 17$, for instance, pertains not only to the nine triangles for which c is 5, 13, 17, 65, 65, 85, 85, 221, 221, respectively,

p.	q.	a.	b.	c.	α.
2	1	4	3	5	53° 8′
3	2	12	5	13	67° 23′
4	1	8	15	17	28° 4′
4	3	24	7	25	73° 44′
5	2	20	21	29	43° 36′
6	1	12	35	37	18° 55′
5	4	40	9	41	77° 19′
7	2	28	45	53	31° 53′
6	5	60	11	61	79° 37′
7	4	56	33	65	59° 29′
8	1	16	63	65	14° 15′
8	3	48	55	73	41° 7′
9	2	36	77	85	25° 8′
7	6	84	13	85	81° 12′
8	5	80	39	89	64° 29′
9	4	72	65	97	47° 55′
10	1	20	99	101	11° 25′
10	3	60	91	109	33° 24′
8	7	112	15	113	82° 22′
11	2	44	117	125	20° 37′
11	4	88	105	137	39° 58′
9	8	144	17	145	83° 16′
12	1	24	143	145	9° 32′
10	7	140	51	149	69° 59′
11	6	132	85	157	57° 13′
12	5	120	119	169	45° 14′
13	2	52	165	173	17° 30′
10	9	180	19	181	83° 58′
11	8	176	57	185	72° 3′
13	4	104	153	185	34° 12′
12	7	168	95	193	60° 31′
14	1	28	195	197	8° 10′

but also to the triangles (576, 943, 1,105), (1,104, 47, 1,105), (264, 1,073, 1,105), and (744, 817, 1,105).

If the product of the three prime numbers contains one factor twice, it can be split in the two ways:

$$(p_1^2 + q_1^2)^2\,(p_2^2 + q_2^2)$$
$$= [(p_1^2 - q_1^2)\,p_2 - 2p_1\,q_1\,q_2]^2 + [2p_1\,q_1\,p_2 + (p_1^2 - q_1^2)\,q_2]^2$$
$$[(p_1^2 - q_1^2)\,p_2 + 2p_1\,q_1\,q_2]^2 + [2p_1\,q_1\,p_2 - (p_1^2 - q_1^2)\,q_2]^2$$

and the two angles α are $2\alpha_1 \pm \alpha_2$. The number $c = 325 = 5 \times 5 \times 13$ thus pertains to the triangles (36, 323, 325) and (204, 253, 325).

If c is the cube of a prime number in the table, for instance, 125, only one set remains, as

$$(p_1^2 + q_1^2)^3 = [(p_1^2 - 3q_1^2)\,p_1]^2 + [(3p_1^2 - q_1^2)\,q_1]^2,$$

and $\alpha = 3\alpha_1$. Similar considerations permit of finding the possibilities if c is the product of more than three prime numbers in the table, without the necessity of squaring the high numbers involved.

FOREIGN ELECTRICAL ENGINEERING PRACTICE.—Mr. C. W. Marshall, B.Sc., A.M.I.E.E., in a lecture delivered in London to the Association of Supervising Electrical Engineers, on Tuesday, January 20, 1948, outlined the main features and the factors which have influenced the layout of the electricity-supply systems in France, Germany, Sweden and Denmark. He explained that the predominant factor, especially in Sweden, was the availability of water-power in districts which are remote from industrial centres. Problems of high-voltage transmission over long distances therefore received earlier consideration than in Great Britain, Germany being a pioneer in this field of development. Both France and Sweden now have 220-kV systems and plans for 400-kV supplies. From an engineering standpoint, Mr. Marshall and other speakers favoured the idea of a Continental grid, designed to link up the various European sources of power and supply systems.

FLUORESCENT LIGHTING AT THE COAL FACE.—A fluorescent-lighting installation has recently been completed by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, at the Chislet Colliery, Kent. This is the first of a series of nine, which are to be carried out for a Committee of the National Coal Board to determine the suitability of this form of lighting in mines. The fittings, which are of the flameproof type, incorporate either one or two 15-watt lamps, which measure 18 in. by 1 in., and are suspended directly over the conveyor at intervals of about 5 yards. The necessary chokes and starting switches are also included. Perspex covers are used, which provide a light distribution co-axial with the tube. Current is supplied from a gate-end box containing a controller, earth-leakage trip and transformer, which steps the voltage down to 120 volts. Connection is made through a four-core screened cable, two cores of which carry the lighting current, while the third and fourth are the pilot and earth wires, respectively. Control is by an electrical interlock, which automatically cuts off the current if the cable is severed, or if a coupler or lamp is disconnected.

DIESEL ENGINES UNDERGROUND.*

By L. B. BERGER, M. A. ELLIOTT, JOHN C. HOLTZ and H. H. SCHRENK.

(*Concluded from page 96.*)

DURING the use of Diesel locomotives in construction of the tunnels, a number of observations of the composition of the tunnel air were made by representatives of the Bureau of Mines. The observations included the collection and analysis of samples of tunnel air and measurement of the carbon monoxide content of the air by the use of a portable carbon monoxide indicator. The results of these analyses, summarised in Tables IV and V, on this page, represent conditions at times when the composition of the tunnel air was affected mainly by the exhaust gases from the Diesel locomotives and not by gases produced during blasting. From Tables IV and V it may be noted that the observed values for carbon dioxide, carbon monoxide, and oxides of nitrogen in the tunnel air were within limits generally considered permissible in the air of working places. The carbon dioxide content of the air, in so far as these analyses show, never reached a concentration significant from the standpoint of toxicity; carbon monoxide was observed in concentrations of 0·01 per cent. in only 5 out of 161 determinations, and the concentration of oxides of nitrogen was never observed to reach 25 parts per million. It may be noted, also, that the oxygen content of the tunnel air was never observed as less than 20 per cent., and averaged less than 0·2 per cent. below the oxygen content of normal air.

A number of determinations were made of the composition of the engine exhaust gas of the locomotives under various operating conditions from idling to the condition existing when the locomotives hauled heavy loads at speeds up to 20 miles an hour. Under normal operating conditions, the maximum carbon monoxide concentration observed in the exhaust gas of the engines was 0·08 per cent. It is pointed out that these observations were made under normal operating conditions with engines in a proper state of repair. Several instances were reported in which the locomotives produced smoke in excessive quantities because of mechanical imperfections or improper adjustment, and although no analysis of the exhaust gas was obtained when such conditions developed, it is likely that production of carbon monoxide increased also.

The maximum concentration of oxides of nitrogen observed in the exhaust gas of the engines while the locomotives were in use in the tunnels was 652 parts per million; somewhat less than was observed (996 parts per million) in the preliminary tests of the first locomotive before it was put into service. The maximum observed carbon dioxide content of the engine exhaust was 10·08 per cent., which may be interpreted as indicating that in this instance 90 per cent. of maximum power was being developed (assuming that delivery of the fuel pumps of the locomotives was limited so that maximum fuel-air ratio attainable would be 0·05 pound per pound, as recommended on the basis of preliminary tests of the first locomotive).

As previously described, the exhaust gas of the engine was diluted with air from the radiator cooling fans before being discharged from the locomotive into the surrounding atmosphere. Thirty-five samples of the final exhausts of the locomotives were collected under various operating conditions. The maximum carbon dioxide content observed was 1·71 per cent., the maximum carbon monoxide was 0·02 per cent., and the maximum content of oxides of nitrogen was 26 parts per million. These results support the conclusion that no serious hazard from toxic gases would be created by the exhaust in the immediate vicinity of the locomotive, provided adequate ventilation was supplied in the tunnels.

The extent of dilution of the engine exhaust before its discharge from the locomotive may be estimated by comparison of the carbon dioxide content of the engine exhaust with that of the final exhaust at a given condition of operation, as shown by the ratio:

$$\frac{\text{Carbon dioxide content of engine exhaust, per cent. by volume.}}{\text{Carbon dioxide content of final exhaust, per cent. by volume.}}$$

In preliminary tests of the first locomotive, before it was put into service, the average ratio thus obtained was 10·8, and similar data obtained when this locomotive had been in use in the tunnels for about a week showed an average ratio of 8·6, whereas after 6 months' service an average dilution ratio of only 3·4 was found in tests of the same locomotive. This decrease in the effectiveness of the exhaust-dilution system appeared to have been caused by accumulations of dust in the cores of the radiators and accumulations of soot on a screen in the exhaust outlet of the locomotive, both of which conditions acted to restrict the volume of air moved by the radiator-cooling fans. As the fans are belt-driven, there is the possibility also that wear or stretch in the fan belts may have reduced the efficiency of the fans. These points regarding the exhaust dilution system illustrate the necessity for careful attention to seemingly minor details in the maintenance of Diesel locomotives in underground use.

The odour and irritating effects of the exhaust gas of Diesel engines are caused mainly by aldehydes, which occur in the exhaust in varying amount, depending on several factors, such as the fuel-air ratio, engine temperature, and the condition of the fuel-injection equipment of the engine. If the exhaust gas contains a high concentration of aldehydes, it is definitely irritating to the eyes and nasal passages; in fact, the irritating effects are more noticeable than the odour if one is exposed to a high concentration of the exhaust gas. If the exhaust is diluted with a large proportion of air, as in the general atmosphere of a ventilated tunnel, the irritating effect is not evident, but a characteristic odour remains, even though the aldehydes are present in the air only in extremely low concentrations.

Perception of, and reaction to, the odour of Diesel exhaust vary with the individual, some persons finding the odour quite unpleasant, whereas others do not consider it particularly disagreeable. For this reason, it was difficult, from discussion with men at work in the tunnels, to evaluate exactly the odour produced in the tunnel air by the Diesels. At such times as the writers observed the odour in the general tunnel atmosphere during tunnel driving, it could, in their opinion, be classed as "faint." It was observed that some of the locomotives first installed were more prolific producers of aldehydes than those put into service later. This may have been an indication that more careful and frequent attention should have been given to the injection equipment of the engines.

Several occasions on which a locomotive produced decidedly offensive odours and an abnormal quantity of smoke have been reported. In so far as the writers have been able to learn, all such occurrences were traced to mechanical imperfections or maladjustments of the equipment. Operating conditions that cause production of excessive smoke and odour by a Diesel engine are likely to produce abnormal quantities of carbon monoxide also.

Some smoke is produced by Diesel engines throughout the normal operating range, even under the most favourable conditions, but excessive smoke usually is indicative of faulty adjustment or improper operation. Among the commonest causes of production of excessive smoke are imperfectly functioning injection valves and operation under "overload" conditions; that is, when more fuel is injected at or near full throttle than can be burned by the quantity of air present in the cylinders for combustion. Excessive smoke may be due to accumulations of dust or soot in the intake and exhaust systems of the engine, which restrict the flow of intake air or exhaust gas and thus alter the characteristics of combustion in the engine.

During tunnel driving, when considerable quantities of explosives were used, it was sometimes difficult to differentiate between smoke produced by explosives and smoke that might have been produced by the Diesel locomotives. It is believed that in some instances poor visibility in the tunnel caused by smoke or fog was erroneously attributed to the Diesel locomotives, whereas the smoke actually had its source in the explosives used in blasting.

Probably the most valuable lesson learned in the use of Diesel locomotives in construction of the Delaware Aqueduct was the importance of proper maintenance of the equipment. The present-day Diesel engine is a complicated mechanism, all parts of which must function properly to produce the maximum in performance. Furthermore, minor maladjustments that might not cause serious faults in performance may result in marked increases in the production of some of the toxic or objectionable constituents of the exhaust gas. It is important, therefore, that the following points be given particular attention in the use of Diesel engines underground:

1. *Fuel-Injection System.*—The fuel-injection valves should be inspected frequently, the length of the intervals between inspections being determined by experience with the equipment. Leaking injection valves, or those delivering an imperfect spray pattern, should be repaired or replaced promptly.

2. *Fuel Quality.*—Cleanliness of the fuel and care in fuel handling to exclude foreign matter are extremely important. Very small particles of dirt in the fuel can damage the injection valves, and the resultant imperfect operation of the valves will increase the quantities of carbon monoxide, aldehydes, and smoke produced by the engine. Fuel specifications should conform with those recommended by the manufacturer of the engine. The sulphur content of the fuel should not exceed 0·2 per cent., as otherwise the sulphur gases in the exhaust will cause undesirable contamination of air of underground working places.

3. *Intake and Exhaust System.*—It is important that the intake and exhaust systems be examined frequently to insure that there are no undue restrictions to flow of intake air or discharge of exhaust gas. Accumulations of dust or soot in air cleaners, flame arresters, or exhaust scrubbers impede the flow of intake air or exhaust gas, which, in turn, will affect the characteristics of combustion in the engine and will increase production of carbon monoxide and soot, particularly at or near full-throttle operation.

4. *Dilution of Exhaust Gas.*—The Diesel locomotives were equipped with an exhaust dilution system to prevent high local concentrations of exhaust gas in the immediate vicinity of the locomotive. Tests of the locomotives in use showed that the efficiency of the dilution system tended to decrease with length of service. It is evident that attention should be given to all parts of the exhaust dilution system to maintain its efficiency at the maximum.

From the described observations on the use of Diesel locomotives in construction of some of the tunnels of the Delaware Aqueduct, it may be concluded that with proper maintenance of the equipment and adequate ventilation Diesel-powered equipment may be used in tunnelling operations without creating hazardous or unduly objectionable conditions in the atmosphere.

TABLE IV.—SUMMARY OF RESULTS OF ANALYSIS OF TUNNEL AIR DURING TUNNEL DRIVING.

Constituent of tunnel air.	Total number of Determinations.	Summary of Results.				
Carbon dioxide	92	Average concentration, per cent. by volume				0·14
		Maximum concentration, per cent. by volume				0·33
Oxygen	92	Average concentration, per cent. by volume				20·78
		Minimum concentration, per cent. by volume				20·38
Carbon monoxide, as determined by chemical analysis	92	Range of concentrations, per cent. by volume	0	less than 0·01		0·01
		Number of determinations	83	6		3
Carbon monoxide, as determined by portable indicator	69	Range of concentrations, per cent. by volume	0–0·002	0·002–0·005	0·005–0·01	0·01–0·015
		Number of determinations	37	22	8	2
Oxides of nitrogen	24	Range of concentrations, parts per million, by volume	0–5	5–10	10–15	15–20
		Number of determinations	19	4	0	1

TABLE V.—SUMMARY OF RESULTS OF ANALYSIS OF TUNNEL AIR DURING TUNNEL LINING.

Constituent of Tunnel Air.	Total Number of Determinations.	Summary of Results.				
Carbon dioxide	28	Average concentration, per cent. by volume				0·12
		Maximum concentration, per cent. by volume				0·21
Oxygen	28	Average concentration, per cent. by volume				20·80
		Minimum concentration, per cent. by volume				20·41
Carbon monoxide, as determined by chemical analysis	28	Range of concentrations, per cent. by volume	0	Less than 0·01		0·01
		Number of determinations	22	6		0
Carbon monoxide, as determined by portable indicator	17	Range of concentrations, per cent. by volume	0–0·002	over 0·002		
		Number of determinations	17	0		
Oxides of nitrogen	24	Range of concentrations, parts per million by volume	0–5	5–10	10–15	15–20
		Number of determinations	11	5	7	1

* Reprinted from Report of Investigations, No. 4032, United States Bureau of Mines. (Abridged.)

EQUIVALENT METRIC VALUES IN SCIENTIFIC PAPERS.

We have received, from the National Physical Laboratory, a report summarising the proceedings at a meeting held in London on December 12, 1947, to discuss a proposal, originating at the Royal Society Empire Scientific Conference in June, 1946, that, where scientific papers or text-books are expressed primarily in British units, provision should be made to include either the metric equivalents or the appropriate conversion factors. A resolution to that effect having been adopted by the Conference, in July, 1947, a letter, signed by the Presidents of the Royal Society and of the British Association, the secretary of the Department of Scientific and Industrial Research, the Director of the National Physical Laboratory and the chairman of the British Standards Institution Council, was sent to various scientific and technical societies and publishers, drawing attention to the resolution and suggesting that a meeting, representative of the various interested organisations, should be held to discuss its implementation.

Replies to the letter indicated a considerable measure of support for the proposal, and on December 12, as stated, a meeting was held in the rooms of the Royal Society. This meeting was arranged by the National Physical Laboratory and the Director of the Laboratory, Sir Charles Darwin, took the chair. As an experiment, National Physical Laboratory papers, since the Conference, have, as far as possible, provided metrical equivalents whenever English units have been used. A paper was therefore prepared at the Laboratory setting out, with examples, ways in which this aim could be achieved, and this was circulated to learned societies and institutions and to publishers of scientific text-books and periodicals to provide a basis of discussion at the meeting. Thirty-eight societies and 35 publishers accepted this invitation and sent representatives.

Sir Charles Darwin, in opening the meeting, emphasised that the matter to be discussed was one of intelligibility only, and had nothing to do with the introduction of the metric system in Britain. By making it possible for the foreigner to convert British units immediately into metric units, publishers would assist Britain to attain the position of the centre of science in Europe. A little more work would be entailed on the part of both authors and publishers, but, he suggested, the addition of a few days to the time normally required for the production and publication of a book was not to be weighed seriously against the great loss of time to all the readers if they had each to look up appropriate factors and make the conversions for themselves. He then referred briefly to the experience gained at the National Physical Laboratory since the Scientific Conference; this was incorporated in the paper which was circulated at the meeting for consideration.

Mr. F. A. Gould, a member of the staff of the National Physical Laboratory, in describing the methods of inserting metric equivalents or conversion factors put forward in the paper, said that these incorporated in some way the principle of double entry; for example, where a numerical quantity was cited in the text in English units, the metric equivalent would be given in parentheses. In some cases, such a method would become unwieldy and other devices were suggested. Where the whole text was full of numerical quantities, recourse might be had to a table of conversion factors at the beginning of the paper. Where a numerical table was printed, the conversion factors might be given at its foot, and sometimes, to avoid the danger of blunders in the conversion, a single row of the table might also be given in metric form. One of the most effective methods was in diagrams, where, in most cases, it would be possible to insert additional scales in the metric units.

In the general discussion most speakers expressed a strong dislike of a proposal to give conversion charts in the form of bookmarkers, as these were troublesome to print and were easily mislaid, and suggested as an alternative the use of a "pull-out." To minimise the additional labour required, there was also a rather natural tendency to favour the method of inserting a list of conversion factors at the beginning of the paper, rather than to give converted figures in the text itself. The additional paper and extra expense involved in a large amount of double entry, as, for instance, in tables, made such a method unpopular with publishers; but it was agreed that, in diagrams, it would be possible to mark ordinates on the left in the British system and on the right in the metric system.

The British Medical Association representative outlined the methods which that Association had used without difficulty for some 12 months, and mentioned how much the inclusion of metric values had been appreciated. A recent document produced by the Association without metric equivalents had brought many protests. Some speakers, in mentioning the need for an authorised list of conversion factors, suggested an extension of the list contained in British Standard Specification No. 350.

In summarising, Sir Charles Darwin said that, although there were obvious difficulties to be overcome in dealing with the problems concerned with the insertion of suitable metric information in scientific papers, the representatives at the meeting had shown that there was general support for the policy advocated by the Scientific Conference, and he felt that, by consulting various organisations, an acceptable scheme could be produced. Another general meeting did not seem to be required, and the National Physical Laboratory would produce summarised suggestions for distribution to those interested.

OSCILLOGRAPH-TRACE RECORDER.

As is well known, rapid changes in mechanical and electrical quantities can be translated into visible traces on a fluorescent screen by means of a cathode-ray oscillograph. Any accurate study of the inter-relationship of these phenomena, however, is made difficult by the impermanence of the "readings," and this also makes subsequent checking impossible. Attempts have been made, therefore, with varying success, to photograph these traces by standard cameras and, in fact, during the war Messrs. Avimo, Limited, Herbert-street, Taunton, designed equipment by which they could be recorded side by side on continuous film or paper. As, however, the number of traces which could be thus recorded was limited, the firm have now designed a series of recording cameras with built-in cathode-ray tubes. This enables as many as 15 traces, as well as a timing interval, to be recorded on a scale adequate for practical purposes. We understand that a camera of this type has been incorporated also in a photo-acoustic recording unit, which has been designed and made to the special requirements of the Ministry of Supply.

The apparatus consists essentially of an Avimo six-channel camera with built-in cathode-ray tubes, the latter being arranged so that their traces are photographed through a mirror. There are also six photo-cell microphone pick-ups, which are suitably placed round a target within a radius of 2,000 ft. These pick-ups consist essentially of a case which is mounted on an anti-vibration chassis and is provided with trunnions, the latter being, in turn, carried on telescopic legs, so that the unit can be directed at any angle and its height varied. This case is fitted with a door, which carries a $\frac{1}{16}$ in. opal-glass screen, the latter being mounted in front of a glass colour-filter cell, which contains a suitably coloured solution and serves as a correction filter for the photo-cell spectral response. The case also contains a vacuum photo-cell, a carbon microphone and a cathode follower valve, which is controlled by a relay, as well as two potentiometers, one of which acts as a pre-set microphone attenuator and the other, in addition, as a capacitor for high-frequency compensation. Current is provided by a dry cell and there is a container for silica-gel, so as to prevent the window from becoming misted. Each of these pick-ups transmits the light of the flash and its sound in the form of an electrical impulse, so that both its intensity and distance from the camera can be determined.

The camera, with its electronic amplifiers and control equipment, is housed in a van and is connected to the pick-ups by cables. The signals from the pick-ups are recorded as linear traces on six 1½-in. cathode-ray tubes which are built into the camera. The maximum length of the trace on each screen is 1 in., and this is reduced to 10 mm. on the film. The standard 70-mm. perforated film or paper in 100-ft. lengths is used and a microscope is provided, so that the traces can be viewed while recording is taking place. The cathode-ray tubes are mounted in a mu-metal shield, which is arranged so that the light from the tube heaters has a minimum effect on the film. It is also possible to orientate each tube in its mounting, so that the traces lie in one straight line on the record, which is at right angles to the direction of film travel. This adjustment is not affected by normal vibration and handling. A range of six film speeds—about 1, 2½, 5, 10, 25 and 50 in. per second—is obtainable.

SMITH BROTHERS AND COMPANY (HYSON), LIMITED.—The founder of the present firm of Smith Brothers and Company (Hyson), Limited, Hyson Green Valve Works, Nottingham, was Sydney Smith (1803-84), for whom it is claimed that he was the "inventor, original patentee and first manufacturer of a steam gauge." An excellent portrait of Sydney Smith forms the frontispiece to a brochure produced by the firm to mark the occasion of their centenary in 1947; though there is a touch of artistic licence in the use, on a later page, of an illustration of the Rocket, which, in fact, was fitted with a mercury-column gauge, supported from the chimney.

ANNUALS AND REFERENCE BOOKS.

Crabtree Electrical Handbook.—A second edition of this handbook has now been issued. It was first published in 1941, and its popularity is shown by the fact that it was out of print within a few months. Publication of a revised second edition, however, has been delayed by paper restrictions. Pride of place is perhaps naturally given to tumbler-switch wiring and applications, as well as to details of the accessories produced by the firm. An interesting section, however, is devoted to the development of standard plugs and socket outlets, although the recent decision to standardise a new 13-ampere pattern was taken too late for details to be included. A great deal of useful information on control gear is also provided; and the arrangement and size of the handbook are of a style which should make it appeal to those for whom it is primarily intended. Among other features is a list of abbreviations in common use, but this might have been extended. The publishers are Messrs. J. A. Crabtree and Company, Limited, Walsall, and the price is 2*s.* 6*d.* net.

The Highway Engineers' Reference Book.—During the past 30 years, highway engineering has undergone a radical change. Owing to the requirements of fast-moving vehicles, old rule-of-thumb methods are being generally abandoned in favour of more scientific technical practices. As a result, the available books on the subject are usually out of date to some extent, so that a reference book containing a symposium of modern ideas is welcome. The present book is grouped into eight main headings: surveys, soil stabilisation, lay-out, lighting, materials, equipment and maintenance. The advisory editor is Mr. E. Stead, late county surveyor of Somerset, and he has been assisted by a panel of contributors including Mr. A. J. Lyddon, late chief engineer, Ministry of Transport, and two prominent county surveyors, Mr. W. P. Robinson and Mr. E. C. Boyce. The early sections provide a comprehensive and sound exposition of modern highway engineering, though it is possible to discern some bias in the chapters provided by specialist manufacturers of materials; for instance, the writer on concrete joints emphasises that expansion joints are necessary, a matter still open to question as far as this country is concerned. Nevertheless, the book is well produced, clearly written and provided with good illustrations, as well as a useful trade section. It is published by Messrs. George Newnes, Limited, Tower House, Southampton-street, W.C.2, at the price of 30*s.* net.

Bibliography of Cement and Concrete.—This booklet has been compiled and issued by the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1, from whom it may be obtained by approved applicants. It is a list of books and papers in London libraries on cement and concrete. The libraries are those of the British Museum, the Cement and Concrete Association, the Chemical Society, the Institution of Civil Engineers, the Institution of Structural Engineers, the Patent Office, the Science Museum, the Royal Institute of British Architects, and the London Library. The list is arranged in chronological order of the year of publication, with the authors' names in alphabetical order under each year, followed by the title of the book, the town of publication, the number of pages, whether there are any tables, diagrams or illustrations, and an indication of the library or libraries in which the book is to be found. An alphabetical index of authors, with cross-references to the main index, is given at the end of the booklet. The list appears to include only those books, reports, etc., which deal specially with cement and concrete, and not books on wider topics with chapters on the subject, or papers read before institutions and recorded in their proceedings. No attempt is made to indicate the nature of the information contained in the books, beyond that given in the title. The bibliography includes over a thousand books.

Nickel Cast Iron.—A loose-leaf pocket-size book of data on the production, properties and applications of nickel cast iron has been published by the Mond Nickel Company, Limited, Grosvenor House, Park-lane, London, W.1. It is a revised and amplified edition of a similar book, first produced in 1939, which has proved of considerable value as a work of reference for the use of ironfounders and engineers concerned with cast iron. The contents are divided into 20 sections, or chapters, dealing with such matters as the effect of additions of up to 2 per cent. of nickel on grey cast iron, various types of nickel and nickel-chromium cast irons, high-strength cast irons, cupola design and air blast, foundry coke for cupola melting, the choice of raw materials, typical charges, foundry technique, and the heat treatment of alloy irons. A graph for converting tensile strengths in pounds per square inch to tons per square inch, and another giving the weights, in pounds per foot, of cast iron round bars of diameters up to 9 in., are also included. Copies of the book are obtainable gratis on application to the company at the address given above.

THE INTERRELATION OF ENGINEERING AND METALLURGY.*

By SIR ARTHUR P. M. FLEMING, C.B.E., D.Eng.

THE introduction of the steam turbine in the later years of the last century brought about a profound change in the production of power, and far-reaching modifications in the design of prime movers and electric generators, involving new problems for the metallurgist. The slow-speed engine-driven generator of pre-turbine days comprised a cast-iron frame which housed an annular ring of thin magnetic sheet-steel laminations forming the magnetic circuit of the stator of the generator. The rotating portion consisted of a spider mounted on the shaft, carrying a steel ring to which the field poles were bolted. The construction of this type of generator, at that time, did not call for qualities of materials which were not easily within the reach of the metallurgist's art. To secure the requisite properties, the modern alternator rotor forging is made of medium-carbon steel which may be alloyed with small amounts of such metals as nickel, chromium, molybdenum and vanadium, thus yielding a product which, while possessing the requisite magnetic qualities, has, after suitable heat treatment, adequate mechanical properties. It is in a product of this kind that the co-operation of the metallurgist and the engineer is most essential.

Although it is of value in determining the quality of light-alloy castings, as for instance, those used in aircraft, X-ray examination is useless for large sections, such as obtain in turbo-generator rotors. Supersonic testing, on the other hand, may be employed up to thicknesses of several feet, as against a maximum of a few inches with modern X-ray equipment. The method, at the moment, is not fully developed but is unquestionably a useful tool. It consists in directing a beam of very high-frequency sound, far above audible frequency, through the metal to be examined; echoes are reflected from the opposite surface of the part and from any defect within it, and analysis of these echoes in a suitable receiver indicates the presence and approximate position of the defect. The method may be modified to meet special requirements, as for instance, by altering the angle of application of the beam so as to locate faults lying in planes unfavourably situated for normal transmission. Magnetic and fluorescent testing methods are also commonly employed for the detection of defects.

The development of the gas turbine and the jet engine has presented many difficult metallurgical problems. The jet engine as used for aircraft, in common with aircraft engines generally, requires to have only a relatively short life of a few hundred working hours, in comparison with the steam turbine which may be more or less in continuous operation for, say, fifteen years. The high temperatures involved in the jet engine, and to a lesser extent in the gas turbine, have called for special alloys, some of which may be of a non-ferrous metal character. An outstanding example is the nickel alloy containing chromium, titanium and aluminium known as "Nimonic," which is largely used for the turbine blades of a jet engine operating at red heat. Alloys have also been used which are unforgeable, and have to be cast to final shape, with only a small finishing allowance.

The metallurgical processes involved in the treatment of uranium in connection with the production of energy from nuclear sources, differs from that with which the metallurgist is normally acquainted, since it necessitates the separation from uranium of one of its isotopes. The preparation of uranium isotopes may not be of great interest to metallurgists in general, but on the other hand it may become of importance to metallurgical research scientists since radioactive isotopes, produced during the liberation of nuclear energy may be used as "tracer" elements in investigating phase equilibria in metals and conditions near crystal boundaries.

The progress of an industry to-day depends increasingly on the collection of new scientific knowledge, and its effective use. In the case of metallurgy, the development of research associations, such as the Cast Iron, Iron and Steel and Non-Ferrous Metals Research Associations, the metallurgical work of the National Research Laboratories and the laboratories at the universities as well as those of the large manufacturing firms, are all contributing continually to the pool of new scientific knowledge. An increasing number of chairs of metallurgy are being created in the universities, and facilities for the part-time study of metallurgy are to be found in very many colleges. Similar developments have taken place in the engineering industry, and a great factor in their mutual progress has been the interchange of the knowledge of producer and user, a co-operative effort which is of fundamental importance in the future progress of both industries.

* Lecture delivered before the Institute of British Foundrymen, London, on Friday, January 16, 1948. Abridged.

LABOUR NOTES.

A MEMBER of the Amalgamated Engineering Union suggests in the course of a letter to the Editor of the organisation's *Monthly Journal*, that in elections of officers, the "political affiliations" of candidates should be given the same prominence in the ballot papers as their ages, etc. "Thus," he says, "giving the membership an opportunity of ensuring that their votes are cast in conformity with Union policy and the obvious political opinion of its members." "It must be realised," he goes on, "that full-time positions in trade unions to-day are akin to public offices which impose a definite code of obligations upon the holder, the most important of which is that such office shall not be used to further the personal or political views of the holder. This view is not being honoured within the A.E.U.; therefore, whether we like it or not, politics must become a factor when filling full-time vacancies, if only to ensure that the trade-union side of our Union can be used to its full effectiveness."

The writer of the letter says he realises that, in claiming that a candidate's political affiliation is the most important thing, he will be met by the pertinent query "What about his trade-union abilities?" "The obvious answer," he writes, "is that all elections, where the candidate's abilities are unknown to the voters are by that very fact in the nature of a gamble. In the absence of any vetting as to the candidate's abilities, the voter is compelled to put his cross and trust to luck. Sometimes, the voter's blind faith is rewarded, and we get a worthy officer whose trade-union abilities are beyond reproach and his political views also coincide with our organisation's political affiliation. On the other hand, we sometimes get some poor unfortunate who was not born to fame, whose abilities are such that he could not achieve it, but through the luck of the ballot just has it thrust upon him."

"In between these two extremes," he continues, "are also what I call the 'cuckoo in the nest.' Usually, he is very able as regards his trade-union abilities, and under this cloak, is able to further his own particular brand of politics which can differ enormously from the declared political policy of the A.E.U. Quotations from his speeches are reported in both the local and the national Press as a member of the A.E.U. and the members who voted for him find that the A.E.U., and consequently themselves, are coupled with a political party whose views are contrary to their own and Union policy."

Branches of the United Society of Boilermakers' and Iron and Steel Shipbuilders are balloting this month in the election of a successor to Sir Mark Hodgson, who is due to retire shortly from the General Secretaryship of the union. There are four candidates—Mr. A. Green (Hull), Mr. E. J. Hill (London), Mr. Q. V. Luker (Swindon) and Mr. F. A. Stamp (Stockton). In his circular to members this month, Sir Mark Hodgson says: "All the candidates have declared that they are not members of, nor connected, in any way, with the Communist Party." Mr. W. F. Whitley, who is also not a communist, has been elected assistant general secretary by a clear majority over six other candidates.

In a message circulated by the Post Office Engineering Union executive council, members are told that it is their duty to make a point of regular attendance at branch meetings in order to exercise their right in the selection of branch officers and conference delegates and to ensure that union business has priority over other matters that may be dealt with. The executive claim that the influence of communists and their sympathisers in the Trade Union Movement is out of all proportion to their numbers. That influence, it is stated, is increasingly used to undermine confidence in present union leadership. Every effort is made to secure support in poorly attended branch meetings for numerous organisations and objects that have the open or disguised blessing of the Communist Party. And the vagaries of that party's policy, it is added, are reflected in the resolutions which flow into the Union head office from the branches affected.

Mr. Lincoln Evans, general secretary of the Iron and Steel Trades Confederation, and a member of the General Council of the Trades Union Congress, also holds strong views regarding the activities of communists. Writing in the January issue of *Man and Metal*, he claims that the British Trade-Union Movement is one of the main pillars of our democratic system. "There is, therefore," he says, "an obligation and duty on each member to be vigilant in seeing that its foundations are not sapped by people who are ever ready to offer lip service to the ideals which give the Movement meaning and purpose, but who would not have the slightest compunction in using the Movement, even to the point of its destruction, in the service of a ruling class other than their own. The heart of the British Trade Union Movement is sound; it is only in apathy that danger lies. To-day, more than ever, eternal vigilance is the price of liberty."

Discussing the question of steel production in the same issue of *Man and Metal*, Mr. Lincoln Evans says that "in agreeing to operate the melting shops continuously through the week-end," members of the Confederation in the Heavy Steel Section, refrained "at this stage in the national interest" from pressing for the 42-hour week in mills and melting shops—a claim which is an essential part and condition of the continuous scheme, "and I wish to make it clear," Mr. Lincoln Evans intimates, "that neither the employers nor the Government can expect this claim to be withheld much longer when a shorter working week is being applied on an ever-increasing scale in other industries. The iron and steel industry has, therefore, to base its plans for the future, and adjust itself, to a 42-hour week on the continuous processes, for it is our intention to proceed with the claim immediately the present national crisis has been overcome."

The Ministry of Fuel and Power states that voluntary absenteeism at the coal face in British mines during the week ended January 3, was higher than it had been since the middle of November, and overall, the highest since the week ended August 23 with the exceptions of the Christmas and New Year holiday weeks. The percentage for voluntary absenteeism at the coal face were 15·68 in the week ended January 3, 7·24 in the week ended January 10, and 9·84 in the week ended January 11, 1947. The figures for involuntary absenteeism at the coal face were 8·76 per cent. in the week ended January 3, 5·83 per cent. in the week ended January 10, and 7·74 per cent. in the week ended January 11, 1947.

Speaking in Manchester last week, Mr. Arthur Horner, general secretary of the National Union of Mineworkers, said that the people were entitled to ask whether the Coal Board, immature, travelling on uncharted way, learning by trial and error, and with a complete monopoly of our coal resources, could reach the new target of 211,000,000 tons this year. The Board had given evidence of its intention to be a good employer. At a cost of 60,000,000*l.* a year, it had raised the mineworkers from the degrading position of being 86th from the top of the industrial wage scale to an honoured position among the most highly-paid operatives in the country, and, in addition, supplementary compensation, fatality and pension schemes were to be discussed. If that was mollycoddling the miner, he could only say that for the first time for many years free British citizens were volunteering to work in the industry.

"In December, 1946," Mr. Horner continued, "we had 692,000 men, and it was estimated that by now we should have only 650,000. In fact, we had 718,822 last week—a net increase of 26,000 representing recruitment of nearly 100,000 men when set against the average wastage of 70,000 each year. Without the reforms conceded by the Coal Board, recruitment could never have gone ahead on that scale. As a minimum, we must have 730,000 men for 1948. In 1949 and 1950, we want to do more and return to the output of 1939 which was 231,000,000 tons with 766,000 men to get it. Output per man-shift has reached nearly pre-war level, but the aim is two tons per manshift as against 22 cwt. or 23 cwt. now. That must be done, not by the exploitation of the physical energy of the miners, which has nearly reached its limit, but by technical developments."

An increase of 7*s.* 6*d.* a week in the wages of adult cotton-weaving workers was announced in Manchester last week. Juveniles, elderly, and disabled workers, engaged on less than a full complement of machines are to get increases ranging from 3*s.* 6*d.* a week. The trade unions which claimed an increase of 10*s.* a week for adults, had refused an offer by the employers of an attendance bonus. About 100,000 workers are affected.

COURSES FOR RAILWAY BOILERMEN.—The London Midland Region of British Railways have arranged one-day refresher courses for boilermen and stokers at three centres: Leeds, Birmingham and London. The elementary principles of combustion and the importance of air control in promoting efficiency of the furnace will be taught. There will be demonstrations, and the men will be encouraged to ask questions and state their own problems.

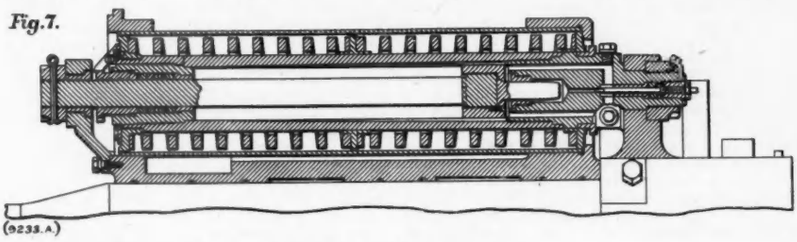
PROBLEMS ENCOUNTERED BY THE R.E.M.E. IN THE FIELD.*

By MAJOR-GENERAL SIR E. BERTRAM ROWCROFT, K.B.E., C.B., M.I.Mech.E.

THE work of the Corps of Royal Electrical and Mechanical Engineers included the inspection, maintenance, modification and repair of all electrical and mechanical equipments in the Army. I have selected problems affecting guns, armoured fighting vehicles, transport vehicles, and the passage through the sea (in amphibious operations), of all natures of equipment, to give a picture of typical mechanical engineering problems which faced us from time to time. Lest these sketches should convey the impression that design and production were seriously at fault, I must stress that equipments were designed and produced during the war under compulsion of such speed of production that nothing like the recognised time was available to develop the perfect article, while the distribution of production and processes—sometimes even of design—between a number of independent firms and departments, while achieving the desired speed of production, opened the door to difficulties in inspection, in the working of tolerances, etc., which were almost bound, in a few instances, to react unfavourably on the performance of the earlier equipments.

My first subject is some teething troubles of the 6-pdr. gun, which gave us all some worry in 1942. This country, with its standard 2-pdr. tank and anti-tank weapon, was behind the Axis in early 1942. Great hopes were then centred on the 6-pdr., supplies of which, both as an artillery weapon and as a tank weapon, were beginning to appear in the second half of 1942, some 140 having been shipped to the Middle East on the eve of El Alamein, and a larger number being in units or in reserve equipments in the United Kingdom.

Fig. 7.



(9233.A)

Our consternation may be imagined, therefore, when the discovery was made, in August, 1942, that, owing to certain combinations of tolerances, the tank version of the gun, when used for sustained rapid fire in excess of eight or ten rounds, was liable to jam, due to expansion of the barrel within its cradle. This discovery led to a minute check of all the drawings and assemblies, in the course of which—and as a result of "defect reports" from users—the following defects came to light.

The cradles constructed of manganese bronze were liable to distortion from internal stresses after manufacture. This distortion affected the freedom of the barrel to run back after recoil, and also affected the clearance of the piston in the recuperator cylinder. The tolerances of barrel and cradle, if all operating one way, could give a clearance when cold of only 0·005 in. With the exercise of rapid fire the gun, especially the barrel, quickly heats up; and 30 or 40 rounds (rapid fire) was sufficient, in the cases of weapons with the least clearance permitted by the tolerances, to cause the barrel to jam completely in the cradle.

As a corollary of the first defect, the alignment of the recoil piston and rod in the buffer cylinder was thrown out. Fig. 7, on this page, shows the assembly of the recoil system. Very fine clearances were laid down, and there could be as little as 0·001 in. between piston and cylinder. Consequently, any misalignment or bad machining, and the least expansion of the piston "out of step" with expansion of the cylinder, led to a further jam. The minimum allowable clearance of 0·001 in. was, owing to the 50 per cent. greater coefficient of expansion of the bronze piston as compared with the steel cylinders, wholly taken up by a rise in temperature of 120 deg. C. (248 deg. F.).

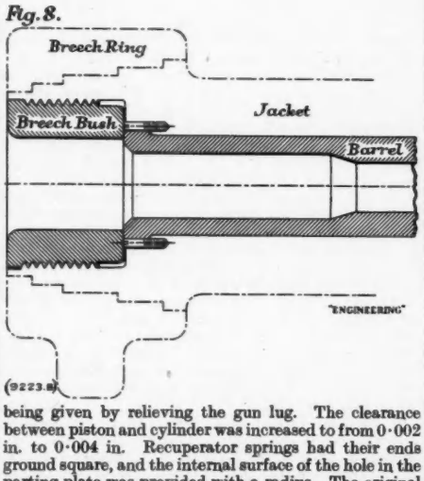
The recoil spring was a close fit in its casing. The main troubles here were, first, the provision of too little clearance between the spring-parting plate (the spring itself was in two portions separated by this plate) and the buffer cylinder; and second, bowing of the springs caused by the spring ends not being square. These faults also caused jamming.

Finally, the semi-automatic bracket showed an alarming tendency to break. This bracket carries a cam, against which a roller on the breech mechanism strikes during the run out of the gun, thus causing automatic opening of the breech, extraction of the spent cartridge, and cocking of the firing-pin. Displacement of the cam, with resultant failure of the automatic action or the shattering of the bracket, were the possible results of this fault.

This was a formidable series of faults, all admittedly rectifiable, but time was short and the troubles did not all come to light together. To remedy distortion of the cradle, every gun had to be dismounted from its tank, and checked with a special gauge made by the Ministry of Supply. Those found to be distorted within reasonable limits, were honed to give a minimum clearance of 0·007 in. between barrel and cradle. To ensure free run of the barrel in the cradle, every barrel and cradle was measured with a micrometer. Any with a clearance of less than 0·007 in. were brought to this clearance, either in the process of relieving the distortion of the cradle, or by scraping and smoothing the barrel, or (in the worst cases) by rejecting the barrel in favour of one made to lower external dimensions within the tolerances permitted by the drawing. Fortunately, enough low-limit barrels were available to meet immediate needs in most cases. About 60 per cent. were found to be defective, of which 20 per cent. were beyond local adjustment.

The buffer cylinders were checked at the same time for alignment, freedom of action for the pistons being given by relieving the gun lug. The clearance between piston and cylinder was increased to from 0·002 in. to 0·004 in. Recuperator springs had their ends ground square, and the internal surface of the hole in the parting plate was provided with a radius. The original semi-automatic brackets could not be strengthened satisfactorily, and a new bracket was produced by the Ministry of Supply, and the exchanges carried out by the R.E.M.E.

Fig. 8.



(9223.B)

The work required on each task was considerable, amounting to about 80 man-hours. The number of distorted cradles found was considerable, too, but most of them were so little out of alignment that they could be rectified. The proportion of barrels which required exchanging was 20 per cent., while most recoil assemblies required rectification. All semi-automatic brackets had to be exchanged eventually, although an attempt was made to stiffen them by fitting a plate. All recoil springs, on both tank and artillery mountings, had to be modified.

The work was done in time; and I only heard of one 6-pdr. failure through faulty recoil in the early stages of the attack. This one jammed after two or three rounds only, so the trouble may not have been due to any dimensional faults. The 6-pdr. gun was a success until outmoded by further improvements in tank and anti-tank artillery and, after this inauspicious start, never gave any serious trouble. That the confidence of the troops in the new weapon was not undermined at the start (a fatal and by no means unknown occurrence), was due to the very prompt and effective remedial measures taken.

The ammunition for the 5·5-in. medium howitzers was produced with several alternative charges; and it was, very reasonably, assumed that they would be employed largely at short ranges, using the lower charges and suffering a comparatively slow rate of barrel wear. The German practice of holding defensive positions in great depth, however, meant that our medium artillery, to neutralise the rearward enemy positions, had to fire at extreme ranges. The 5·5-in. howitzers were very frequently employed in heavy concentrations of fire at these extreme ranges, using the maximum charges of propellant and incurring the maximum wear. I mention this as one illustration of the effects of tactics on weapon and equipment design and maintenance.

Complaints were received during the north Africa and Sicily campaigns that 5·5-in. howitzer barrels were developing severe oval wear and consequent scoring, with the result that their useful life was reduced to less than 50 per cent. of that expected. Investigations were put in hand by the Ministry of Supply in this country, and by the R.E.M.E. in Italy. The symptoms of the defect were oval wear at bottom centre ("down"), at the start of the rifling, after about 700 full-charge rounds; and ovality which developed to about 0·040 in. after 2,500 rounds, when scoring started at top centre ("up"), and developed so rapidly that barrels were unserviceable at about 2,900 full-charge rounds.

The life of the bore of a gun is determined by several factors. The two effects of gas erosion, namely, wear and scoring, are the most important. The term "wear" is used to denote a general and, usually, more or less even increase in internal diameter as firing proceeds. "Scoring" refers to more severe and localised erosion of the bore. In this instance, scoring started opposite the area of maximum wear when ovality reached approximately 0·040-in. As the weapons were being condemned due to scoring long before the limit of wear was reached, it was thought that, if the ovality could be kept below 0·040 in., scoring would not develop, and the gun would remain serviceable until the limit of wear was reached. The 5·5-in. shell now weighs 80 lb., but at the time of these troubles it weighed 100 lb., which was somewhat heavy for this calibre, and it was thought that this weight was causing the initial wear. Experiments were therefore put in hand to rotate the barrels, at intervals, through various angles to equalise the wear.

The 5·5-in. howitzer is fitted with a loose barrel, which is prevented from turning by two grub screws located half in the lip of the barrel and half in the jacket in which the barrel is carried, at top and bottom centres, respectively, as shown in Fig. 8 on this page. To reduce machining, the rotation of the barrels in "steps" of 90 deg., as soon as ovality reached 0·010 in. was tried. This only entailed cutting two extra slots for the locating screws, and was moderately successful.

Rotating the barrels through 120 deg. as soon as ovality reached 0·010 in. was tried next. This entailed cutting four extra slots, but was very successful; it almost completely prevented scoring, and increased barrel life to the full estimated duration of 6,000-7,000 full-charge rounds. To simplify machining, R.E.M.E. workshops manufactured a suitable jig. Fig. 9, on page 118, shows the ovality of a barrel at 2,500 full-charge rounds without turning, when scoring started. Figs. 10 and 11, on the same page, show the effect of turning barrels at intervals of approximately 700 and 400 full-charge rounds, respectively. All these experiments were carried out in the field on guns which were in action, and the experiments had, therefore, to be carried out as and when conditions permitted.

The commonest cause of an offensive dying out is the failure of the attacker, through lack of resources, through restriction of communications and through difficulties of maintenance, to replace casualties in men and material, either by bringing in fresh men and machines, or by "repairing" men and machines on the spot. The equipments most vulnerable to both mechanical and battle damage are tanks. In the 1914-18 war, our tank losses in each major action averaged about 50 per cent., so that, with a limited stock and a limited output of new tanks, we were able to put fewer and fewer tanks into battle in each succeeding attack from August, 1918, onwards.

In the 1939-45 war, the Germans, with standardised equipment and more lavish scales of repair personnel and material, started well ahead of us in mechanical maintenance, and with growing experience they eventually reached the very high standard of forward recovery and repair displayed by the Afrika Corps, where disabled tanks were snatched out of the battle line, repaired in the vicinity, and returned to the fight within hours.

The creation of the R.E.M.E. afforded opportunity for the reorganisation of our maintenance services on new lines, which featured the strengthening of the forward repair echelons at the expense of those farther back, and, as time and opportunity offered, increasing and improving the equipment at the disposal of these

* The Fourth James Clayton Lecture, read before the Institution of Mechanical Engineers, London, on Friday, December 19, 1947. Abridged.

ROYAL ELECTRICAL AND MECHANICAL ENGINEERS IN THE FIELD.

Fig. 9.

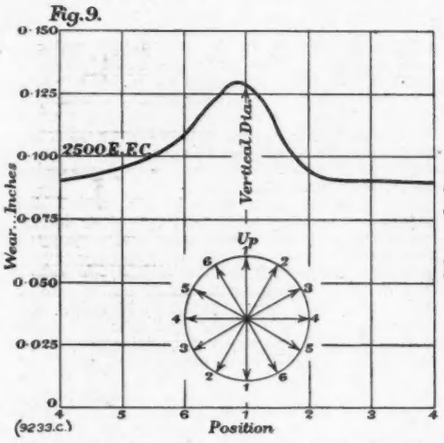


Fig. 10.

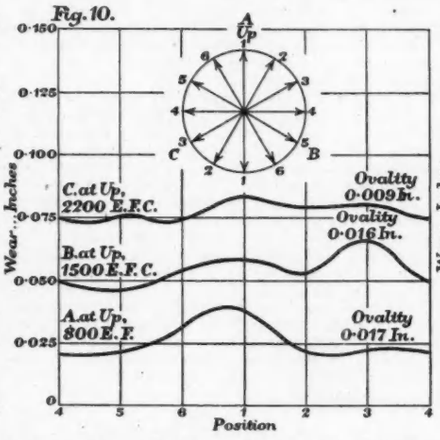
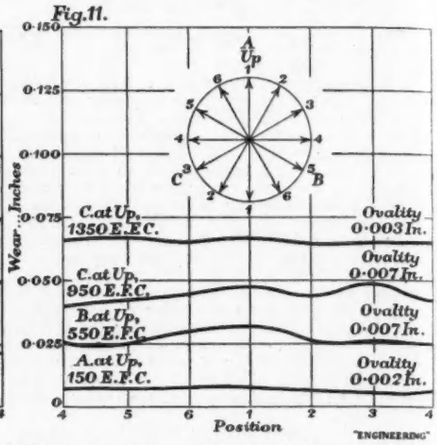


Fig. 11.



forward echelons. In the early campaigns in the Middle East we lost out of the battle line, through enemy action and mechanical breakdown, over 80 per cent. of the tanks which became casualties; that is, less than 20 per cent. were repaired and returned within a few hours, while over 80 per cent. were evacuated to the base for repairs. As this evacuation had to be made along a most congested line of communications, hundreds of miles in length, the system was impossibly slow. With some slight improvements in technique and recovery vehicles, the proportion rose by mid-1942 to between 40 and 50 per cent. repaired forward; but this was not enough.

When the El Alamein campaign was staged, the R.E.M.E. had just been formed; new establishments in men and equipment had been drawn up, but, particularly as regards the latter, these establishments had not yet been filled. Our basic recovery vehicles were 3-ton breakdown lorries, useless in sandy or rough terrain; six-wheeled four-wheel drive tractors (Fig. 1, on page 108), excellent in all but the softest sand; and "D.8" tractors (Fig. 2, on the same page), carried on wheeled trailers behind American six-wheeled four-wheel drive tractors. For the carriage of immobilised tanks, we had a few articulated transporters and a greater number of tractors and trailers.

None of these machines was ideal, but, combined, they put up a most creditable performance at the cost of much man-power, time, and improvisation. Our calculated requirement in six-wheeled tractors alone was over 230; we had 29. On the eve of the battle, some vehicles in reserve were brought out of the vehicle depots of the R.A.O.C., and swelled our numbers to a little more than twice the original. For the rest, we had to rely on our own ingenuity and hard work, our new principles of maintenance, and on the generous support, whenever possible of the R.A.S.C. Tank Transporter Companies, whose real work was the carriage of live tanks into action, not the removal of the damaged ones.

Nevertheless, through improved technique and some slight increase in equipment, but most of all through the re-deployment forward of much of our resources, the proportion of casualty tanks restored to their regiments in a matter of hours rose sharply to 83 per cent., and never, in any theatre of war, did it subsequently fall appreciably below this figure.

We were not satisfied, however, with the wheeled and tracked recovery vehicles at our disposal, especially with the opening of the European front or fronts in mind, and since February, 1942, a study had been made of the possibility of adapting a fighting-tank hull to recovery purposes. By mid-1942, a prototype Churchill A.R.V. (armoured recovery vehicle) had been produced. In this machine, the turret was removed and a flat hinged lid was substituted. A jib, drawbars, flame-cutting equipment, and a certain amount of fitters' gear were carried, together with "spuds," holdfasts, tow ropes, and snatch blocks. There was, however, no winch and no heavy-lift jib; that provided was capable of a 3-ton lift only. A number of these A.R.V.'s accompanied the expedition to North Africa in 1942, where they earned golden opinions, but the need for a powerful winch and a heavy-lift crane was demonstrated.

A little later, in Italy, the British Army were fortunate to obtain a few American "T.2's," recovery tanks on "Grant" hulls with a mechanically-operated winch and a high-lift jib. These proved invaluable for recovery work in mountainous terrain, where it was frequently impossible to get a straight pull and a clear run for the recovery vehicle.

Meanwhile, we had been pushing on with the idea of the jibbed and winched A.R.V., and eventually, after many vicissitudes and an intensive search for production capacity in the United Kingdom, we produced, for issue in 1944, the A.R.V. Mark II in its Churchill form, and in its Sherman form (Fig. 3, on page 108). The salient features of these machines were the winch drive, giving a pull on the rope of up to 60 tons, the armoured accommodation for the winch operator in a dummy turret, the dummy gun, and the powerful 9½-ton fixed jib at the rear end, with a 3½-ton detachable high-lift jib at the front. Finally, to enable the rear jib or the winch to exert the necessary lift or pull, a substantial earth anchor was fitted at the rear, of a simple, robust, and quick-acting type. The amphibious development of this machine—the "Beach A.R.V." (B.A.R.V.)—will be dealt with later.

Owing to the absorption of all Ministry of Supply design and production capacity on existing programmes of work, the entire design and production of A.R.V.'s and B.A.R.V.'s were carried out by the R.E.M.E., using R.E.M.E. workshops and two small civilian establishments (Hayes Plant and the L.P.T.B. Railway Workshops, Fulham) made over to us by the Ministry of Supply. The winches and drives were produced for us by Messrs. Crofts. The research, design, and production of prototypes were carried out at the R.E.M.E. Experimental Recovery Section and Experimental Beach Recovery Section, at Arborfield and Budleigh Salterton, respectively.

We claim that the A.R.V. Mark II was ahead of any other country's equipment of similar type, comparative trials having been made with equivalent American and German equipment, the former yielding to the A.R.V. in the matter of maximum winch pull, thickness of turret armour, and earth-anchor capacity, and the best of the latter (developed on "Tiger" or "Panther" hulls) wholly lacking armoured protection for the crews and having an earth anchor which, though good, was inferior to our own.

During the early part of 1942, chassis failures were experienced on sandy terrain in the Middle East with certain 3-ton transport vehicles. The failure consisted of a chassis-frame fracture across the top flange, approximately 11 in. to the rear of the transfer-box cross-chassis supporting member; and was attributed by the manufacturers' representatives in the Middle East to the severe conditions which caused the body holding-down bolts to work loose, resulting in excessive strain on the chassis members. Prompt action was essential, and a Middle East local instruction was issued to effect a repair by inserting flitch plates, approximately 2 ft. 6 in. long, inside the chassis-frame members. Portions of old chassis frames were used, wherever possible, and any existing holes in the web of the chassis were also utilised. The flitch-plates were relieved at each end by an arrow-head, "cut-away" in the web, to avoid any abrupt change of section.

The modification was a complete success and chassis members of subsequent vehicles produced in North America were reinforced during manufacture. At the time of the failure, there were many thousands of vehicles of the types affected in the Middle East. The time to repair both side members of a vehicle was about six man-hours.

My next theme concerns the preparation of the mass of equipment planned to land on the Normandy coast on "D-Day" and subsequent days, without any dock facilities, piers, or landing stages. Most of our transport vehicles would "wade" up to 1 ft. 6 in., and our fighting vehicles up to 3 ft. in calm water at slow speeds. We had now to cater for entry into water of much greater depth, down a ramp inclined at about 20 deg. to the sea bottom, and to make our way ashore through a moderate surge (1 ft. 6 in. waves were stipulated) as fast as we could, in the face of a lively defence and subject to moving both parallel to and across the path of the waves. We had to be prepared for immersion for half to three-quarters of a mile, and, in the case of certain special equipments, for periods up to 45 minutes or more continuous immersion. There were four main types of equipment to consider, namely, armaments, armoured fighting vehicles, transport vehicles, and miscellaneous equipment such as radar sets, signal vehicles, and trailers.

Armaments were simple, the requirement being to prevent the ingress of water to the barrels, to protect the breech mechanism and traversing gear from damage by sand and water, and to ensure that the towing attachment did not foul the junction between the ramp and landing craft, which had a contained angle of 160 deg. These objects were achieved by plugging the gun muzzle; protecting the breech mechanism and traversing gear by a liberal application of grease (and in some cases by a covering of balloon fabric); and by altering the position of the towing hooks to ensure clearance of the ramp joint.

The design and production of the wading equipment and the necessary modifications for each type of armoured fighting vehicle (A.F.V.) was the responsibility of the Director of Tank Design, Ministry of Supply. When his design was complete for any one type, a "one-off" trial was run at a Ministry wading trial centre, at which representatives of the manufacturer and the Director of Tank Design, as well as of the War Office General Staff and the Director of Mechanical Engineering, were present. If satisfactory, enough equipment was then produced for a large-scale trial in which a sub-unit (such as a troop, squadron, or company of anything up to 12 or 16 vehicles, driven and waterproofed by their own crews) was put over the side. Any weak points, or impractical point when it came to application of the scheme by troops, was eradicated, and trials were continued until the scheme was perfect and accepted by the General Staff. Writing of instruction books, profusely illustrated, and the provision, of bulk stores for all vehicles of that particular type, were then put in hand.

The waterproofing consisted of: the provision of external fittings such as air chutes, exhaust chutes and the protective covering of armament, which was done by the Director of Tank Design and the provision branches; the fitting of angles, brackets, etc., to take these fittings, which was the job of the R.E.M.E.; and finally, the actual waterproofing with a proprietary sealing compound or asbestos compound, of such components and of rivet and bolt heads, welded seams, apertures and joints for armaments or equipment such as periscopes, etc., which was the duty of unit crews. The bringing together of the equipment and the vehicles was a task of no mean order; for the fittings for a tank were of such bulk that only three sets could go into one 3-ton lorry, and a special transport service had to be provided just before "D-Day" to deal with this requirement.

Tanks and self-propelled artillery, being of the nature of closed vessels themselves, gave less trouble in detailed preparation for wading than transport vehicles, but scrupulous care in sealing all rivets, bolts, and welded seams was always necessary. The welded seam rather surprised us, for few of the perfectly sound, shot-proof, and well-executed seams proved to be waterproof. The removal of the external chutes after landing was

ROYAL ELECTRICAL AND MECHANICAL ENGINEERS IN THE FIELD.

FIG. 12. BEACH ARMOURED RECOVERY VEHICLE.

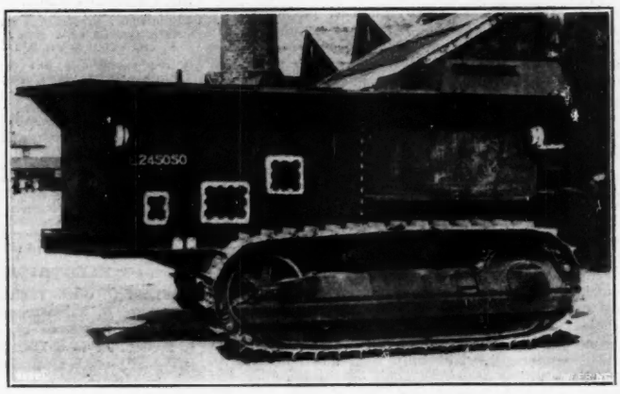


FIG. 13. ARMOURED AMPHIBIAN "D 8" TRACTOR.

FIG. 14. ARMY VEHICLES LANDING; NORMANDY, JUNE 6, 1944.

carried out by automatic means, and fabrics enveloping guns, instruments, air-inlet louvres and turret rings, were blown off by explosive operated by the driver. Fig. 4, on page 108, shows a tank wading.

Among the A.F.V.'s, the armoured and scout cars (owing to the design of their hulls) and the carriers (owing to their tendency to float) gave us considerable trouble. The latter had their sides increased in height by panels secured to brackets welded on to the original structure. A difficulty encountered with certain carriers was the failure of the steering brakes due to the effect of sea water. When these little machines were towing 6-pdr. guns in the water, the brakes failed to grip sufficiently to guide both carrier and 6-pdr.; the driver was forced to move straight ahead in whatever direction he found himself pointing on leaving the ramp, and this was by no means always in a straight shore-ward direction. By grooving the brake linings, we got enough control to make the project practicable; but it entailed the provision of special liners for every towing carrier.

Transport vehicles were the most numerous class of equipment to be waterproofed, and the most difficult. Initially, the Ministry of Supply worked out, with manufacturers, a number of methods suited individually to each make. These were tried in fresh and salt water, approved, and scheduled for use. Large numbers of vehicles were waterproofed under Ministry of Supply arrangements at a depot at Treforest, and were stored for some months prior to March, 1943. Then two difficulties arose: first, it was found that the methods of waterproofing were sound in themselves, but were not suitable for application by comparatively untrained troops; second, a test wade of a number of these vehicles showed that the materials deteriorated in storage.

About this time, the responsibility for waterproofing of equipments passed to the Director of Mechanical Engineering at the War Office, and we set ourselves the task of producing, for transport vehicles, a scheme which would be simple to apply, as universal as possible in its application to the wide range of vehicle types to be covered, and as durable as possible in its results. A special Deputy Directorate at the War Office was formed under the control of Brigadier H. R. Howard, C.B.E., M.I.Mech.E. The co-ordination of the waterproofing schemes, instructions, and trials for all equipment was in his hands, and the actual preparation of the schemes for everything except A.F.V.'s was also his.

I must turn back to the methods evolved by the Ministry of Supply, which came to be known as "the manufacturers' methods." When these were finalised, the materials available were limited. Such parts as electrical fittings (plugs, distributors, etc.) were sealed with a compound known as "pressure plastic," a red wax which hardened on application and produced a very fine gastight and watertight joint. It was rather difficult to apply, being stiff, and great care was required to ensure that the surfaces were clean and free from oil and grease before application. Air and breather intakes and apertures were fitted with pipes which were led up to a height safely in excess of the wading depth, which at this time was laid down as 3 ft. plus 1 ft. 6 in. waves. Exhaust outlets were similarly upswept. The dynamo and starter motor, if not wholly enclosed, were protected by special sealing, or by being placed bodily in a bag of waterproof material.

The drawbacks to all these measures were that the pressure-plastic sealing compound hardened and lifted with long storage; it was difficult to apply, and required great patience on the part of the operator; the bags were difficult to fit and their final watertightness difficult to achieve; and the exhaust uptakes were bulky and extravagant in material, and were found, eventually, to be unnecessary. A compound was produced by one of the petroleum companies in 1943, which offered considerable resistance to the passage of electricity, was comparatively soft and easy to apply, and was obtainable in large quantities. This was known as "asbestos compound," and was a compound of finely-flaked asbestos and a low-melting-point grease of more than average purity. It was not safe to rely on this substance for parts where considerable heat and possible pressure from leaking gases might be met. Here the pressure plastic remained supreme until another more easily worked material, known as "Gripon," became available. This was a white compound and had the two very desirable characteristics of being easy to work and having excellent dielectric properties under varying temperatures. Eventually, these two superseded all compounds previously employed for electrically-insulating coils, starter motors, and dashboard wiring and instruments; and when the depth to be waded was raised in two successive steps by the General Staff, between August, 1943, and June, 1944, these two compounds enabled us to face the increased depth with comparative equanimity.

For the dynamos, it was found that the most effective method was also the simplest, namely, to spray the interior with ordinary engine oil, remove all brush covers and protecting plates, and let the dynamo take a salt-water bath. The exhaust outlet gave us another pleasant surprise. We found that the universal bogey of the motorist in the water splash, namely the possibility of water entering his engine through the exhaust pipe if the engine were allowed to stall, was a myth. This was proved conclusively by stalling the engines of several types of vehicles in an experimental water tank and allowing the engines to cool and stay submerged above the exhaust-outlet level for anything up to 45 minutes. In no case was there ingress of water through the exhaust system, though in some cases there was evidence of water in crankcases, due to normal seepage, aggravated no doubt by the drop of pressure within the crankcases. We therefore abandoned all exhaust-pipe extensions and saved much time, labour, and material thereby.

The waterproofing of the vehicles was carried out as near to "D-Day" as time and labour permitted. Preferably, it should have been done within six weeks of the operation, but we had to fit many vehicles earlier. This covered the first stage, and ensured the proofing of the ignition system, the fitting of extensions to air inlets, breathers, etc. The second stage, carried out by crews a few miles from the point of embarkation, consisted of the preparation of batteries and headlamps, filling and sealing fuel tanks and oil dip-sticks, and a check of the first stage. Finally, at the embarkation point, the distributor was fully sealed (if done earlier, condensation takes place and failure occurs within); the waterproof sheet was fitted over the radiator and under the front of the engine, not to keep out water but to reduce surge under the bonnet; and a last-minute check was made.

With all vehicles, the driver gets a sudden cold bath, at least up to the waist, as he leaves the ramp, and one of the hardest things in training crews is to accustom the driver not to snatch his foot off the accelerator pedal when he gets his bath. A colder and longer immersion is the inevitable result of such squeamishness, but it is a very natural reaction.

One type of vehicle, perfectly—in fact, outstandingly—successful on land, had barely sufficient tractive power under wading conditions to push aside its own volume of water. Another had such fine clearance between piston and cylinder that when the cylinder block was suddenly cooled by immersion, piston seizure occurred. A rush order for refitting (we gave an additional 0·004-in. clearance) some thousands of vehicles with undersize pistons was carried out in an exemplary manner. Carburettor jets had to be changed; engines on Home Service were "jetted down" fairly severely in the interests of petrol economy. On immersion we encountered carburettor failure, so literally tens of thousands of jets had to be changed, during the first stage of waterproofing.

Those who have not experienced it, will have difficulty

in realising the power of even moderate seas when they play on a submerged vehicle. We rarely waded in waves of a size greater than 2 ft. 6 in. to 3 ft., but often wings were buckled, bonnets stove in, and any loose fittings were carried away. Further, particularly if moving parallel to the line of the waves, vehicles were lifted off the sea floor; or, more frequently, the weight on the front axles was so reduced during the passage of a wave that the steering wheel spun free in the driver's hands, until the vehicle resettled. Finally, as all the world knows, the weather broke in June, and we had higher tides and bigger seas on the Normandy coast than had been known, in that month, for 30 years.

Miscellaneous equipment was divided into two categories—equipment which had to be protected from salt water as a complete installation and which we, therefore, sealed in the trailers or containers carrying it (radar sets were the outstanding example); and equipment which could be waterproofed in detail and allowed to become immersed in an open trailer (wireless trailers were the chief examples). In the latter, great use was made of waterproof bags and wrappings. This whole class of equipment gave very little trouble, the chief danger being that of flotation of the completely sealed equipment. Not only did flotation tend to lift the tail of the towing vehicle off the sea floor, but there was also a grave danger, in many cases, of the floating trailer "turning turtle." Such tendencies had to be corrected by judicious weighting of the trailer; but a nice balance had to be drawn between the amount of weighting and the power of the towing vehicle.

To cover possible eventualities, we had calculated losses through drowning of not more than 10 per cent. of all vehicles put through the surf; and the Royal Army Ordnance Corps made provision in their Beach Detachments for a 10 per cent. supply of items such as starter motors, dynamos, batteries, etc. Brake mechanisms could be ignored in this provision, since all that was required, happily, after emerging from the water was some 2 or 3 miles running to dry out any water which had collected in the brake drums; this rough and ready dry-out being followed at the first opportunity by the stripping and cleaning of brake drums, blocks, and actuating gear. The General Staff accepted the risk of 10 per cent. failures.

Fig. 5, on page 108, shows a 10-ton lorry leaving the ramp of a tank-landing craft, and Fig. 6, on the same page, shows a lorry wading. The waves in these pictures are well under the stipulated 1 ft. 6 in. in height, so the vehicles are performing under optimum conditions.

Recovery in amphibious operations is the responsibility of the R.E.M.E., and is a matter of supreme importance on the beaches. Once a start has been made in disembarkation from landing craft to shore, the way must be kept clear of breakdowns and drowned vehicles. This essential principle holds good not only during the journey from the landing craft to the water's edge but also—with added force—at the stage when the shore line has been reached and equipment is necessarily confined to paths cleared by the Royal Engineers through beach minefields. To accomplish this we used, for the under-water part of the work, Beach Armoured Recovery Vehicles (B.A.R.V.'s) and armoured D.8 tractors, which are shown in Figs. 12 and 13, respectively, on page 119. The former were Sherman Diesel-engined tanks, thoroughly waterproofed, with the turret replaced by steel superstructures, so that they can remain immersed for hours in 9 ft. or 10 ft. of water. Coupling and uncoupling under water was done by men wearing shallow-diving apparatus.

Fig. 14, on page 119, shows the passage in progress. The vehicles were a great success, and even achieved a tactical surprise, as on D-Day the first tank-landing craft to touch down was unfortunately the wrong one. It was filled with R.E. vehicles and a B.A.R.V., which took the water first and struck terror into the local opposition. The German *communiqué* spoke of the "new British Goliath tank" being the first to land.

The armoured D.8's had a smaller wading capacity but, their tracks being wider and the track loading lighter than in the case of the B.A.R.V.'s, they did invaluable work in the shallows, and above the water-lines. The armoured, waterproofed hulls of the D.8's were designed and produced by the R.E.M.E. at short notice. In addition to these two types of vehicle, six-wheeled tractors, unarmoured, did yeoman service above the tide-line, and the R.E.M.E. teams, as a whole, kept the beaches clear. Vehicles which broke down were first dragged clear of the traffic lanes and then, at the first opportunity, passed into a "drowned-vehicle park," where they were dealt with by the workshops of whichever brigade was, at the moment, passing across that beach.

The net result of the waterproofing activities of the R.E.M.E. from July, 1943, to June, 1944 (and, be it noted, the spadework done before and after July, 1943, by the Ministry of Supply) was that 99·85 per cent. of the waterproofed vehicles made shore successfully. We had guaranteed 90 per cent.; we were satisfied.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

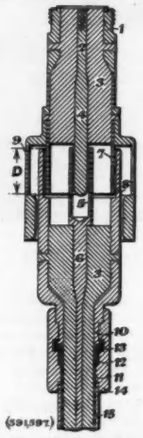
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

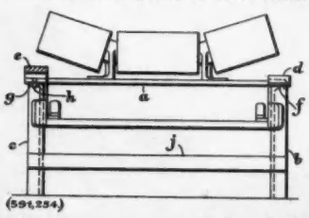
591,597. Ultra High-Frequency Coupling. D. M. Robinson, A. T. Starr and J. B. Adams, of London. (1 *Fig.*) December 18, 1944.—This invention relates to a coupling device for ultra high-frequency apparatus in which relative angular or rotational movement is required between one element, such as a feeder, and another element such as a directional aerial, particularly as used in certain forms of radar equipment. The feeder (not shown) is provided with a screwed coupling which enables its outer conductor to be connected to the screw threaded portion 1 of the fixed section of the rotatable joint. The inner conductor 2, which is embedded in insulating material 3, is formed with a widened end portion 4 which projects within the widened hollow end 5 of the inner conductor of the rotatable portion of the joint, leaving a narrow air gap between them. The end 4 of the fixed inner conductor extends into the end 5 to a distance equal to a quarter of a wavelength at the operating frequency as indicated at D. The continuation 6 of the rotatable inner conductor is embedded in



insulating material 3. The countersunk holes shown in the outer conductor serve to key the insulating material 3 thereto, there being, say, eight of such holes around a circumference. The portion 7 of the outer conductor of the fixed section of the joint extends also for a distance equal to a quarter of the operating wavelength within the portion 8 of the outer conductor of the rotatable section of the joint, leaving a narrow air gap. The outer conductor of the fixed section of the joint is provided with a skirt-like member 9 which covers the capacity coupling and serves to prevent energy at the operating frequency from passing down the outside of the joint from one section to the other. The end of the joint connected to the aerial terminates in a portion 10 of reduced diameter and the continuation of the outer conductor is formed by a flexible-mesh sheath 11 which is retained in good electrical contact with the portion 10 by a flanged sleeve 12, a holding ring 13 serving to secure the portions 10 and 12 together. A moulded sleeve 14 of insulating material protects the joined portions, and the mesh sheath 11 is protected for the continuation of its length by an outer covering 15 of insulating material, the sheath 11 and the inner conductor forming a rotatable feeder. (*Accepted August* 22, 1947.)

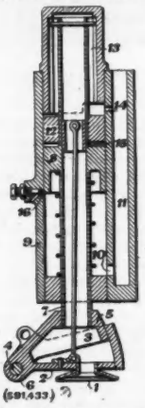
LIFTING AND HAULING APPLIANCES.

591,254. Conveyor Rollers. The Newbiggin Colliery Company, Limited, of Newbiggin-by-the-Sea, Northumberland, and W. H. Stothard, of Newbiggin-by-the-Sea, Northumberland. (3 *Figs.*) May 4, 1945.—The invention is a supporting device for band-conveyor rollers, its object being to facilitate the easy renewal of the conveyor rollers and their supporting sleepers. Each roller-carrying sleeper *a* is mounted on a pair of side frames *b*, *c*, by engaging the ends of the sleeper in fixed cover straps *d*, *e* provided on the top portions *f*, *g* of the frames. The cover strap *d* of the side frame *b* is a snug fit for the sleeper end and is closed at its outer end, so that it prevents end movement of the sleeper *a* in that direction, *i.e.*, to the right. The cover strap *e* of the side frame *c* is open at both ends and is high enough to permit the end of the sleeper to be raised therein sufficiently to disengage one or more pins *h*, projecting from the under face of the sleeper end, from corresponding holes in the top portion *g* of the side frame. The side frames *b*, *c* are of angle-section iron and have diverging legs, the complementary frames of each pair being connected by cross members *j*, which determine the spacing between them. (*Sealed.*)



PRINTING AND ALLIED MACHINERY.

591,433. Sheet-Separating Mechanism. R. Hoe and Company, Limited, of London, and A. P. Battey, of London. (4 *Figs.*) May 10, 1945.—The invention relates to mechanism for separating sheets of paper or cardboard singly from a pile. In the illustration 1 is a pneumatic sucker mounted on a carrier 2 which, with a component 5, forms a chamber 3 to which suction is applied through a tube 7; the carrier 2 is pivoted at 4 so that, if the lower opening in the sucker 1 is closed, the component 2 will be caused to rock on the pivot 4 in an anti-clockwise direction. The tube 7 is attached to, but passes through, a piston 8 in a double-ended cylinder 9 open at its lower end through a port 10 to a suction line 11, the tube 7 passing at its upper end beyond the piston 8 through the upper cylinder wall 12 to a chamber 13 to which the suction line is also open through a port 14. With the parts so far described, the cylinder 9 is stationary and forms the support from which the mechanism is carried. When suction is applied to the line 11 the piston 8 is lowered until the foot 6 engages the top sheet of the pile, at which time the sucker 1 is in a position to make contact with the sheet. The opening of the upper chamber 13 to atmosphere is now closed by the sheet, and a



suction effect is set up in the lower chamber 3, which results in the pivoted carrier 2 being rocked and thus causing the sucker 1 thereon to bend the sheet about the foot 6. In order to lift the now bent-up top sheet, there is formed in the tube 7 above the piston 8 a passage 15 which places the upper side of the piston open to the suction effect set up in the bore of the tube 7. This passage 15 is of small area, as compared with the area of the bore of the tube 7, so that the suction operation resulting in the bending of the sheet is relatively unaffected by the existence of the passage 15. When, however, the rocking of the component 2 has been completed, the suction on the upper side of the piston builds up. The piston 8 now moves upward carrying with it the foot 6, the sucker 1 and that part of the sheet in the region of the sucker. This continues until the suction is cut off, when the separated sheet is taken away by a sheet-forwarding device (not shown), and the parts return the position shown, where they remain until suction is again applied. In order to cause the piston 8 to have, firstly, a slow upward movement and then a faster movement, the cylinder 9 has, above the piston 8 when in its lowest position, a "leak" to atmosphere through an opening 16: this leak prevents the application of full suction to the upper side of the piston until the piston has moved up sufficiently to close the leak. (*Sealed.*)